SERVICE TRAINING COURSE

BOOK NUMBER 6

MONROE

INTRODUCTION TO ELECTRICITY

GENERAL SERVICE DEPARTMENT
MONROE CALCULATING MACHINE CO., INC

SERVICE TRAINING COURSE

Book No 6

MONROE

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- HOW ELECTRICITY IS MADE
- ELECTRIC DISTRIBUTION
- YOUR OWN ELECTRIC PLANT
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1960

F O R E W O R D

As a Monroe Service Trainee, you have received step-by-step instruction via "Service Training Books 1, 2, 3, 4, and 5 which permitted you to become acquainted with the intriguing mechanisms of Monroe Calculators (L to MA-7-W-3) and Adding Machines of the "400", "600" and "800" lines. As a continuance of this mechanical training you will hereafter be studying Calculators "C" and "N" and Accounting Machines (200 and B series) through use of the standard Service Bulletins and via the training schools conducted at Branch, Division and Factory.

The growth of the Monroe Company has continued to produce new and different products such as "Synchro" (punched tape) machines, Card Verifiers, Card Tabulators, Data Log Devices, Distributape Machines, Monrobot etc. Training on these products requires a fundamental understanding on the part of Monroe Servicemen of Elementary Electricity.

The purpose of this book is to introduce you to some of the uses of Electricity as related to our products and review some of the interesting and pertinent data on Electrical Energy. The study of electrical power, virtually, is never ending and many hundreds of books have been written about it by authorities on the subject; however, Training Book #6 is intended to merely "open the door" to the mysterious realm of Electricity.

We trust it will prove interesting and valuable to you.

ELECTRICAL ENERGY

Among the most widely used commodities in your daily life is ELECTRICITY, an energy that cannot be seen or heard but which is continually working for us. ELECTRICITY is in almost everything, though it may not be moving. All we need to do is excite it out, then catch it so that we may use it as we desire. ELECTRICITY is a flow of electrons, the tiny sub-atomic particles found in the outer orbits of atoms. A flow of electricity denotes a flow of these particles which carry a negative electrical charge. This imponderable and invisible agent ELECTRICITY produces light, heat, chemical decomposition and other physical phenomena.

The word 'ELECTRICITY' is a take-off from the Greek language word 'ELEKTRON' and was originated by a Dr. Gilbert, now known as 'The father of electrical science'. Dr. Gilbert died in 1603 at the age of 63 years. From the date, it is evident that there is nothing really new about this intriguing subject. The Greek word 'ELEKTRON' was an ideal basis for 'ELECTRICITY' because 'ELEKTRON' in Greek means 'AMBER.' The yellow-brown translucent, fossil resin, known as 'AMBER', takes a fine polish and by friction becomes strongly electric. This 'AMBER' when rubbed with another material, becomes heated and magnetic. Seven hundred years before Christ was born,the magnetic quality of this polished resin was known in Greece. The Greek 'ELEKTRON' is not unlike the English 'ELECTRON'.

As with other mysterious and invisible phenomena such as the WIND, ELECTRICITY is a powerful fundamental quantity of nature that man has found a way to measure in order to judge its power.

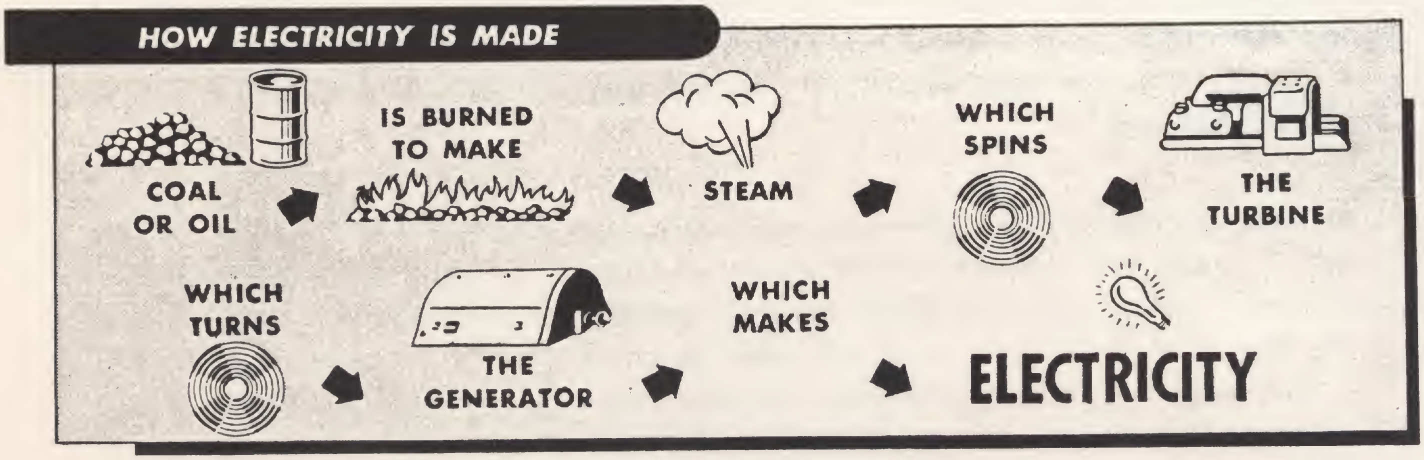
This measuring constitutes an important segment of our modern world of Electricity and its offspring, 'Electronics.'

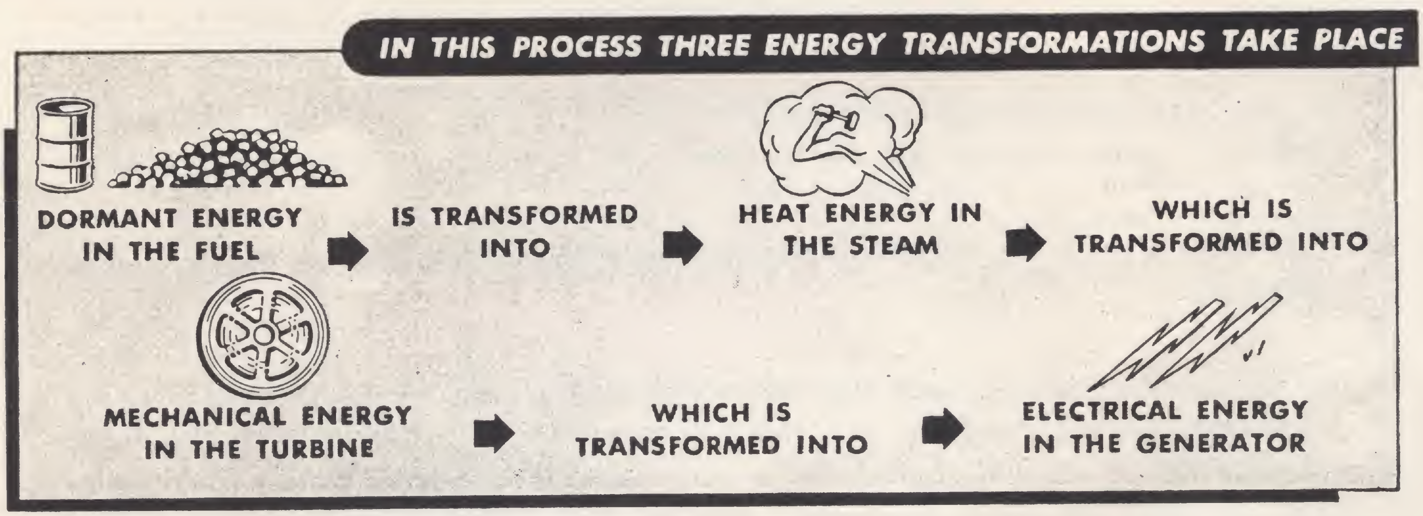
As with Nature's Winds of Tornado Force and Nature's Lightning, man can produce energy in amounts sufficient to harm or kill those who come directly in contact with it. ELECTRICITY can, however, be controlled and safely used in large quantities to run the motors in our factories, produce metals from ore, power our freight and high speed passenger trains and perform hundreds of varied industrial chores.

Our present, immediate concern, however, is not in the use of large quantities of ELECTRICAL FORCE such as is required to move trains, elevators or large motors. We instead will study the use of electricity in the small quantity needed to operate the small motors and components in our office equipment machines. We will attempt to obtain an understanding of how the electrical current is converted, reduced, stepped up, channeled, and controlled in Monroe machines.

The ramifications of ELECTRICAL FORCE are endless and extend far beyond the usage to which we utilize it in Monroe products. Further detailed training can be pursued via a study of the set of five volumes 'BASIC ELECTRICITY' published by John F. Rider, INC. of New York City or other similar simplified courses of instruction.

HOW ELECTRICITY IS MADE





One of the inherent characteristics of electricity is that it is possible to change its form without changing its ability to do work. Thus, for example, voltage may be stepped up or down to suit the requirements of the situation, alternating current may be changed to direct current and back again, or frequency may be varied over a wide range. As electricity comes from the generating machines and before it undergoes numerous transformations on its way to the customer, it is described as being three-phase alternating current having a frequency of 60 cycles per second.

HOW ELECTRICITY IS MADE

Alternating Current and Frequency

As contrasted with direct current such as the discharge from a battery, alternating current not only pulsates but also reverses its direction at each beat, two pulses constituting one complete cycle. Most electric customers in the United States, are served with electric current at a frequency of 60 cycles, or 120 pulsations per second. Two of the many advantages resulting from countrywide standardization of frequency are that it makes possible the transfer of electric power from one system to another without the use of frequency changers otherwise required and it permits standardization in the manufacture of electrical equipment. Incidentally, the speed of electric clocks is directly dependent on regularity of these pulsations, and for that reason, among others, the frequency is permitted to vary only within very small limits and must average exactly 60 cycles.

Single-Phase and Three-Phase

The term single-phase describes a characteristic of current produced by the simplest kind of a generator with a single coil. Such a machine would require two wires to conduct its output to the point of utilization. But by adding two more coils to the generator, it will produce three-phase current which requires only three transmission wires instead of the six one might expect. Consequently, for this and other reasons, many generators are three-phase machines. Some larger users use three-phase power but the bulk of power delivered to domestic customers is single-phase. Fortunately, the process of sorting out three-phase current into three single-phase circuits is easily accomplished in the last steps of distribution.

Units of Electricity

The voltage of electricity is the measure of its pressure and is expressed in volts. Amperage is the measure of its rate of flow and is expressed in amperes. The product of the two gives a measure of apparent power expressed in volt-amperes, or kilovolt-amperes which are 1000 volt-amperes. A watt is the unit of real power and is the product of volts, amperes, and a factor called power factor. In the case of direct current or pure resistance on an alternating-current circuit, this factor is one. For other types of load on alternating-current systems, this factor may range from one down to values of .5 or .6. If 20 fifty-watt light bulbs, having a combined demand of one kilowatt, are burned for one hour, one kilowatthour of energy has been used.

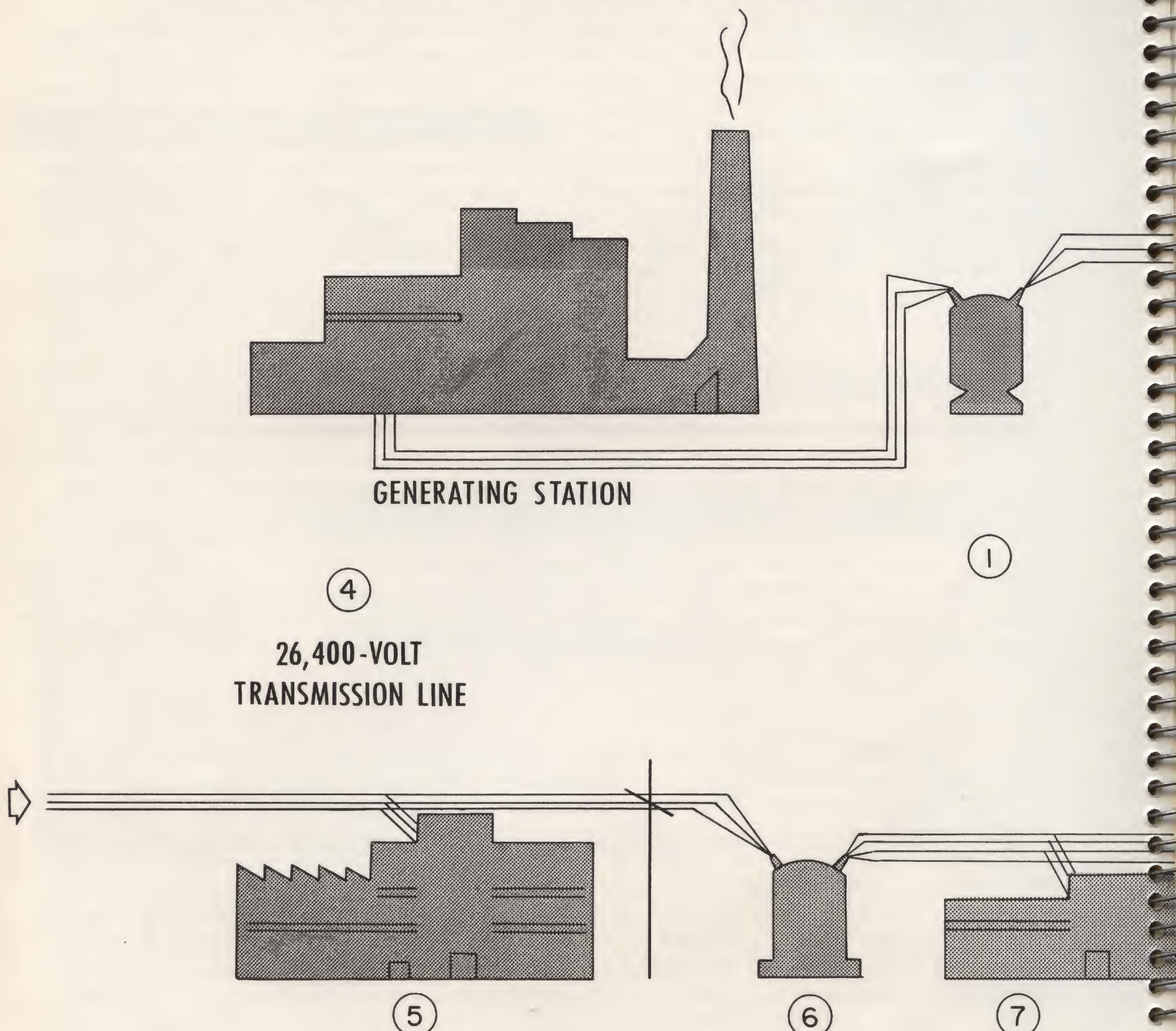
Nature's Electrical Generator

Hot air, rushing upward through cool air at hurricane speed, knocks electrons from water molecules in the rain it has produced at high altitudes. This creates an electrical charge.

Electricity causes lightning which is a rapid flow of electrons through the air between an electrified cloud and the earth, it can also jump from ground to the cloud.

Thunder is merely the sound of the electrons flowing through the air.

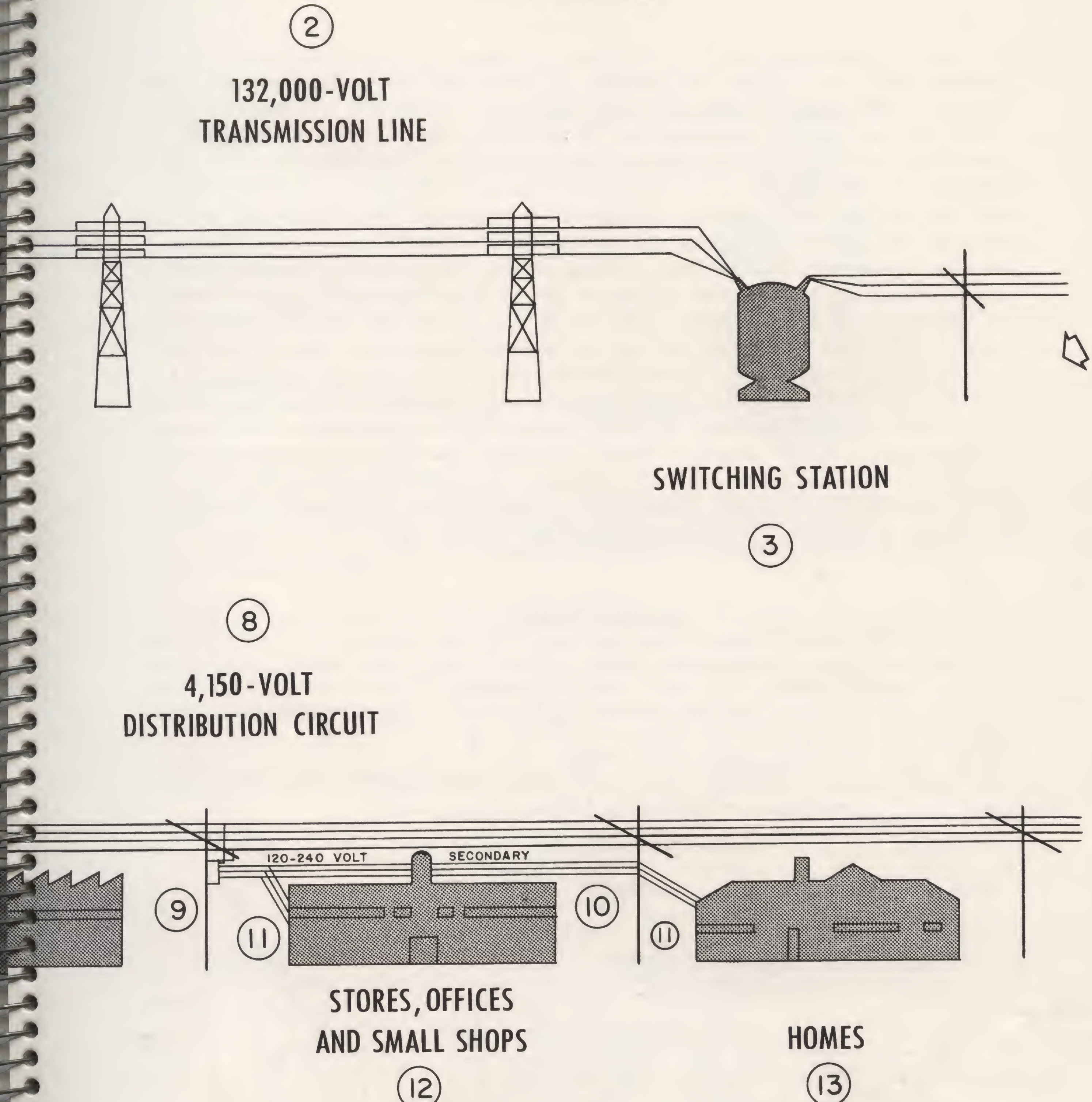
ELECTRIC DISTRIBUTION



FROM SOURCE TO CONSUMER

The voltage at which the electricity is generated at the stations is raised by transformers (1) to 132,000 volts for economical transmission over the steel-tower lines (2) to the switching stations (3). In some instances the voltage is stepped up to 26,400 volts at the generating stations (1) and the electricity sent over wood-pole lines directly to the substations (6); a few circuits between these points carry electricity at 13,200 volts, the voltage at which it is generated. In congested areas, or where open wire construction is not desirable, underground cables are used for transmission. At the switching stations (3), transformers reduce the incoming electrical voltage from 132,000 to 26,400 volts. The 26,400-volt lines (4) radiate from the switching stations to carry electricity to some

DISTRIBUTION

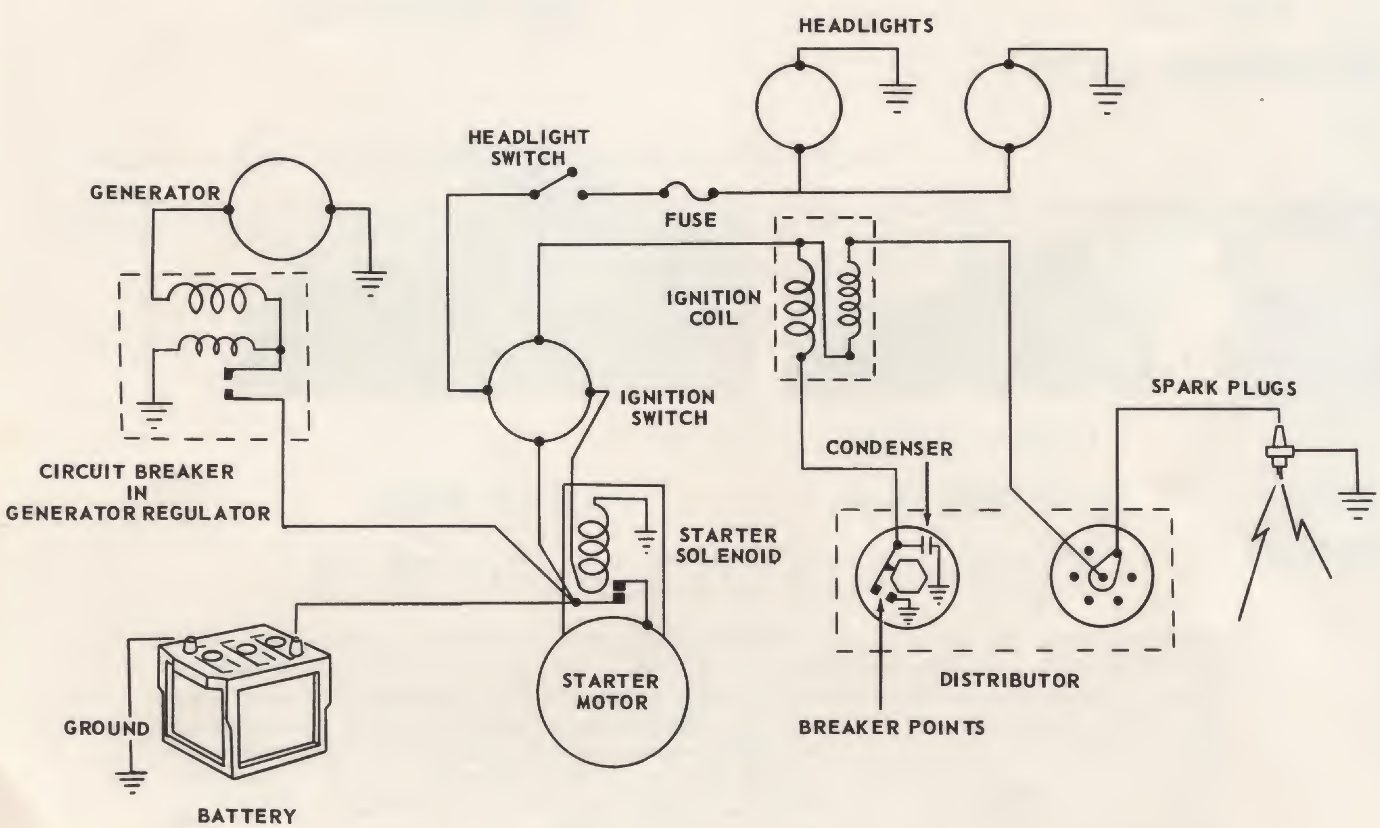


large industries (5) which purchase power at this voltage, and to the numerous substations (6) where the voltage is further reduced to 4,150 volts – the primary distribution voltage. Certain users (7) of electrical energy frequently find it desirable and economical to purchase energy at this primary circuit voltage. The primary lines (8) feed transformers (9), located on the poles, where the voltage is still further reduced to 240 and 120 volts. The electricity then goes out over the secondary lines (10) and service wires (11) to stores, offices, and small shops (12), and homes (13). At the customers' premises the electricity is metered and it is then ready to perform the many tasks and services which we have come to accept as a part of our everyday life.

YOUR OWN ELECTRIC PLANT

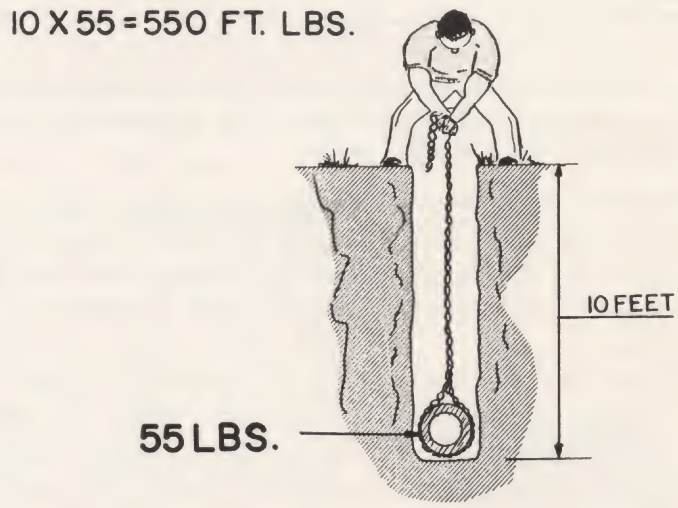
Beneath the hood of your automobile you have an interesting example of electricity being manufactured and utilized. The electrical system is in fact the heart of the automobile. If it fails, your car will not operate. Possibly your first introduction to electricity occurred by observing the manner in which your car generated its own electric current. The self starter of your car is electrically operated, the engine is fired through the ignition system and the head lights, tail lights, stop lights, backup lights, dashboard and ceiling lights, attest to the consumption of electrical current. The gasoline gauge and the speedometer work on an electrical principle. The electric fan for the heater and defroster requires electrical energy as does the cigarette lighter and the car radio. Newer use of electrical energy is occasioned by the car air conditioner, electric windshield wipers and possibly a car phone, and T.V. set. Another source of electrical energy in your car, other than the generator, is the storage battery in which chemical action produces electrical current for use of the starter and lights when the car engine is not operating. Because of its mysterious origin and unlimited usage, the study of electricity is stimulating and rewarding.

Ignition System



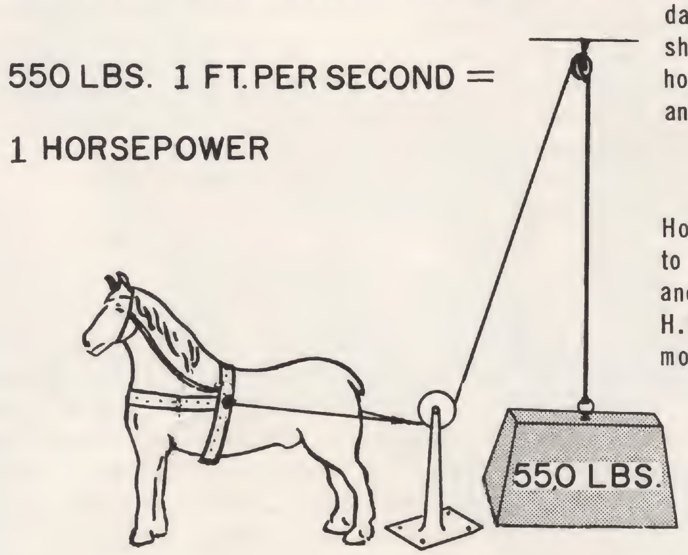
TERMS OF REFERENCE

One of the fundamental units which applies to electricity as well as many other things is the unit of work. In engineering, work is defined as the product of force times distance. It is measured in foot pounds. If you lift a weight of 55 pounds up ten feet, you have done 10 times 55, or 550 foot pounds of work. Likewise, if you push a box across the floor with a steady force of 55 pounds against friction, when you have moved it 10 feet you have again exerted 550 foot pounds of work.



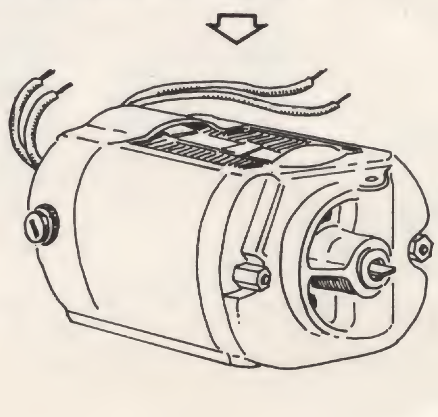
Power and work are terms which are often confused. Power is the rate of doing work. In our preceding examples the time it took to lift or move the object was not considered. Whether it took one second or one minute had no bearing on the work done. Power takes into consideration the time it takes to do the work. If you lift the 55 pound weight 10 feet in one second it will take 550 foot pounds per second of power. If it is raised in 10 seconds it will take 550 divided by 10, or 55 foot pounds per second of power.

Our common measure of power in engineering is the horsepower. James Watt, who developed the steam engine, wanted a unit to compare the work done by his engines in pumping water out of mines with that done by horse-operated pumps. After a series of careful measurements he established that a horse could lift 550 pounds at the rate of one foot per second. This rate of doing work, 550 foot pounds per second, he termed a horse-power. This figure is somewhat more than a horse can exert over a full day's work, but much less than the rate for short sprints. It has been determined that a horse develops 10 horsepower when running and pulling a light buggy.



HORSEPOWER OF MOTORS

Horsepower of Monroe motors range from 1/50 to 1/15. 'K' model machine motors are 1/50 and 1/30 H.P. 'L' and 'M' machines are 1/20 H.P. 'A1' machine motors are 1/15 H.P. 'N' model machine motors are 1/20 H.P.

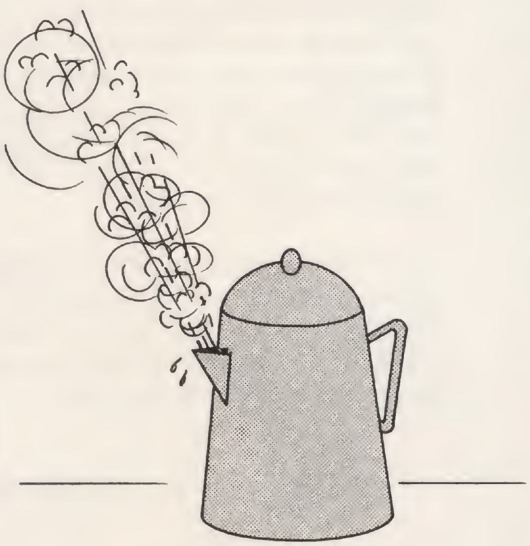


TERMS OF REFERENCE

A man can exert about one horsepower in certain forms of athletics but in prolonged effort 1/10 to 1/15 horsepower is his limit. In the preceding paragraph, it would take one horsepower to raise the weight 10 feet in one second and one-tenth of a horsepower in 10 seconds.

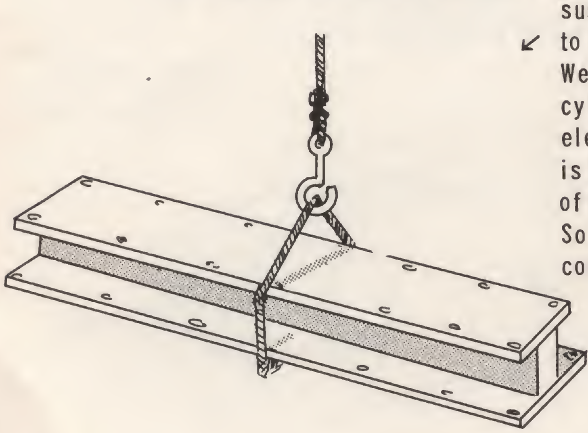
It is not hard to visualize many different ways of developing power. When we look at Niagara Falls we receive a feeling of tremendous power. This huge volume of water dropping a great distance and reaching a high velocity gives great power.

Suppose we perform Watt's experiment with a boiling teakettle. If we leave the lid off, steam will escape in a great cloud but with very little pressure. If we put the lid back on, allowing the steam to escape through a small hole, the pressure is increased and less steam will escape. Steam can escape in large quantities at low pressure or in small quantities at high pressure. An electric current can be likened to the steam. Pressure represents voltage. Quantity represents amperage. These are two fundamental electrical units of measurement. A current can have a high or low voltage (electrical pressure) or a high or low amperage (quantity of electricity). You will recognize that these electrical units are named in honor of the two scientists, Volta and Ampere.



The unit of electrical power is likewise named in honor of a scientist, James Watt, who devised the mechanical unit of power, the horsepower. Power in watts is the product of the volts times the amperes in a circuit. Since a Watt is a rather small unit, the Kilowatt, (1000 watts) is the usual unit in engineering. A horsepower is about three-fourths of a kilowatt and is therefore smaller. A hundred watt electric lamp will use about an eighth of a horsepower, or a little more than a man can exert in steady work.

At this point, another factor is of interest. Energy is practically synonymous with work. Energy is the capacity for doing work. It is measured in the same units as work. Energy exists in many forms. A suspended weight has potential energy by its position. It takes work to lift the weight against gravity but will give up its work if released We have chemical energy in gasoline. When the fuel burns in the cylinder work is done in moving the piston downward. We now have electrical energy. A storage battery stores up chemical energy which is later reconverted into electrical energy. Leaves convert the energy of radiations from the sun into plant stalks, stems, flowers and seeds. So we see that energy exists in various states and can be quickly converted from one to another.



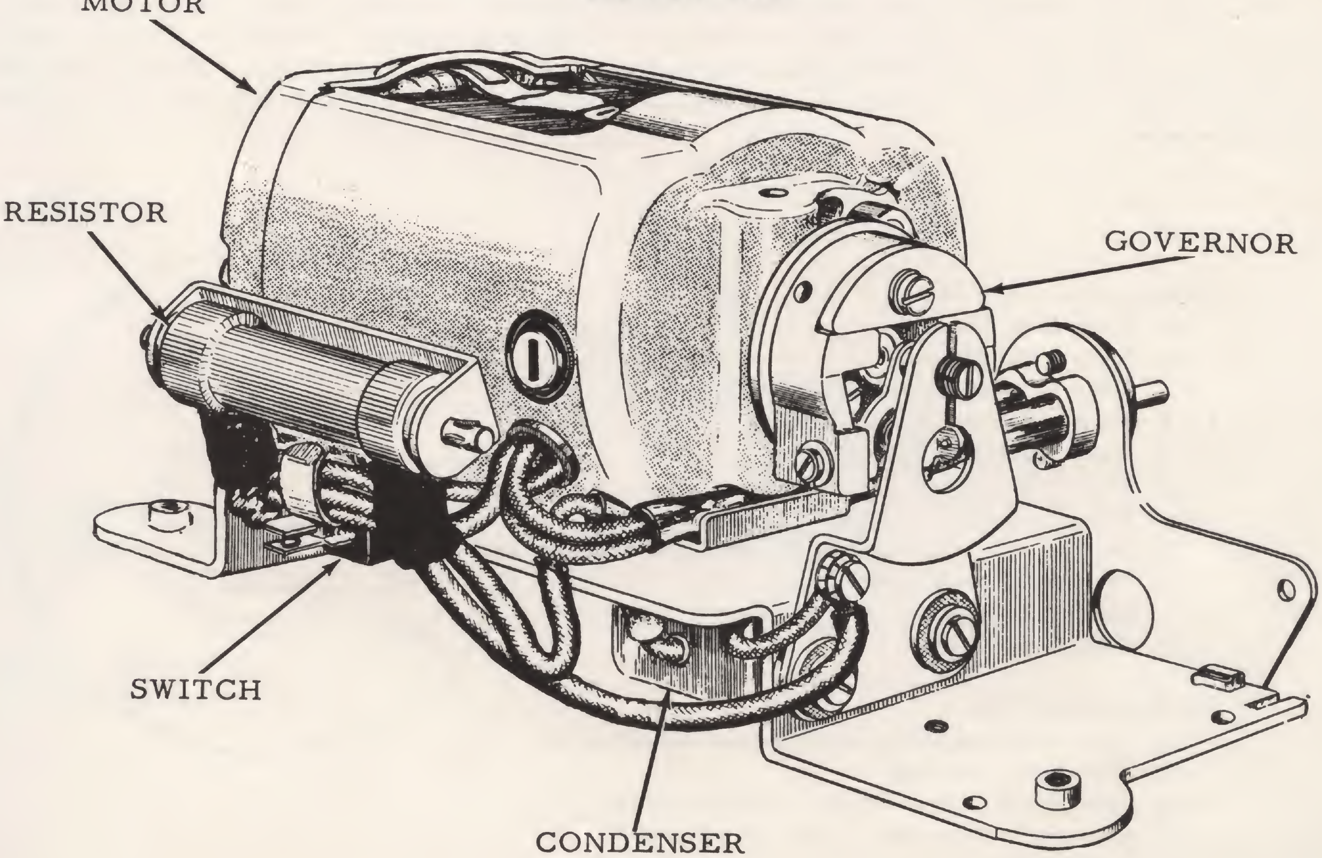
ELECTRICITY AND MONROE MECHANICAL PRODUCTS

Electricity has been employed in Monroe calculators for forty years to drive the rotating shafts and other moving parts. It has also been used in our adding, accounting, and check writing models to provide ease of operation and speed. The electrical unit usually consists of a motor unit and start-stop switch. The motor unit is made up of motor, governor, resistor, condenser, motor jack, and speed-adjusting screw. If radio static interference is encountered by a user of our machines, a cartridge-type suppressor is attached to the motor jack (plug) within the machine. Rigid Navy specifications for Electromagnetic Interference Elimination are complied with through use of a special square-type filter within the machine.

Monroe servicemen have been repairing the electrical section of our electro-mechanical machines for many years by replacing the component responsible for the difficulty. Such repairs, however, did not require the knowledge of electricity that our newer models call for.

To bring you up to date on the electrical section of our mechanical machines, pages **2-F** and **3-F** are provided.

MOTOR UNIT



MOTOR DATA

The following is a brief outline of the operation and functions of the various components used in our motor assemblies.

Universal Motor

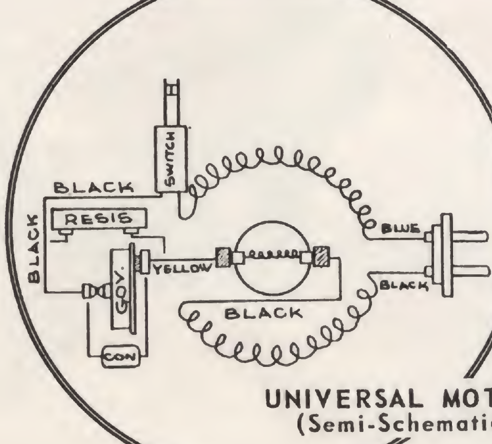
The Universal or Series motors can be used on Direct Current or on Alternating Current of any frequency up to 60 cycles. The operating characteristics and performance on either current is essentially the same. A voltage variation of 10% above or below the rated voltage can be tolerated under normal operation. Where the motor load is light considerably more variation will not adversely effect machine operation.

The Universal Motor requires brushes for commutation and these must be replaced when worn. Infrequently, the armature commutator segments will require cleaning with fine sand paper (not emery cloth). Periodic lubrication is necessary but care should be taken not to over-lubricate to the extent that oil spatters on the governor disc and collects on the governor brush.

The Universal Motor without governor will operate at a speed over 5000 r.p.m. when not under load. A governor and a resistor are added to the circuit in order to enable adjusting for and maintaining a constant speed. When the governor contacts are closed,the path of the current from the line is through one field coil, through the switch if closed, through governor, armature and through the second field coil to the line. When the motor reaches a certain speed the governor contacts open and the current cannot pass directly through the governor to the armature but must now pass through the resistor thereby cutting down the motor speed according to the value of resistor used. Actually in operation the governor contact points are opening and closing many times per second. A condenser is added to the circuit for the purpose of prolonging the governor contact life by reducing the sparking when the contacts open and close. An open circuit in the condenser will result in greater sparking. A short circuit in a condenser will cause the motor to run wild because the current can then bypass the resistor. Resistors seldom cause trouble by breakdown. Troubles mostly encountered in the motor assembly fall into three general classifications:

1) Motor does not run
2) Motor runs wild
3) Motor lacks power

1) Motor Does Not Run:
   a. Line fuse blown
   b. Switch not closed
   c. Worn or sticking brush
   d. No brushes in motor
   e. Open circuit in field winding
   f. Incorrect voltage
   g. Ground, if three wire motor cord is used.
   h. Governor contact screw not making contact
   i. Incorrect resistor value
   j. Motor bearings seized
   k. Incorrect wiring



UNIVERSAL MOTOR
(Semi-Schematic)

2) Motor Runs Wild
   a. Governor regulating screw adjusted in too far
   b. Condenser shorted
   c. Governor hinge stuck in closed position
   d. Ground, if three wire motor cord is used.
   e. Incorrect wiring
   f. Incorrect resistor value

3) Motor Lacks Power
   a. Motor overheated
   b. Incorrect machine or clutch adjustment
   c. Incorrect voltage
   d. Incorrect wiring
   e. Ground, if three wire cord

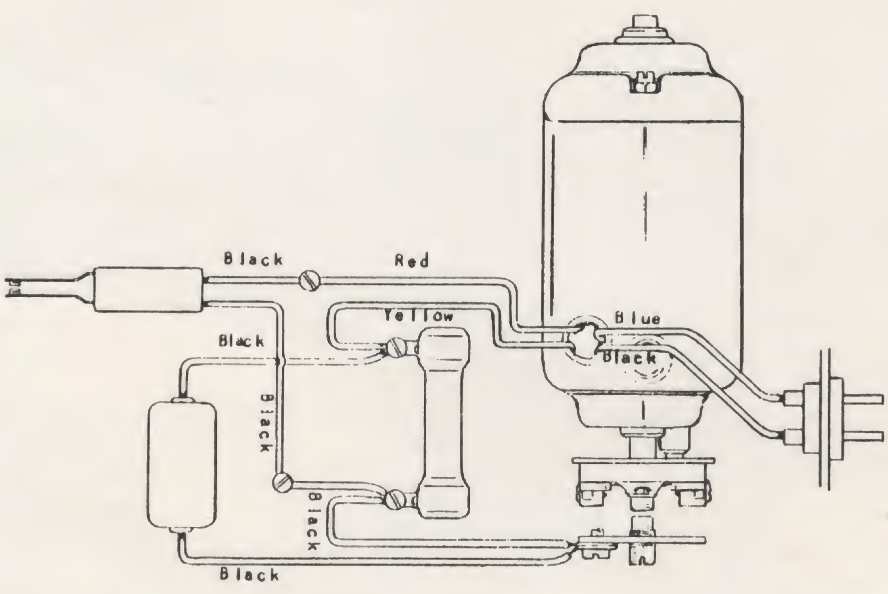
Grounded wiring in the motor or in any component in the motor assembly when using a three wire cord can cause any of the following conditions according to the location of the ground:

a. Blown line fuse
b. Slow speed
c. Motor runs wild
d. No power
e. Motor reverses under no load
f. Motor smokes
g. Motor runs with switch open
h. Field coil burns out

For purpose and value of three wire motor cords, refer to General Service Bulletin #G-512.

If there is a ground and the machine cord plug is reversed the above conditions will change. The above defects will not show up when using a two wire cord except when there is more than one ground in the assembly.

UNIVERSAL MOTOR WIRING

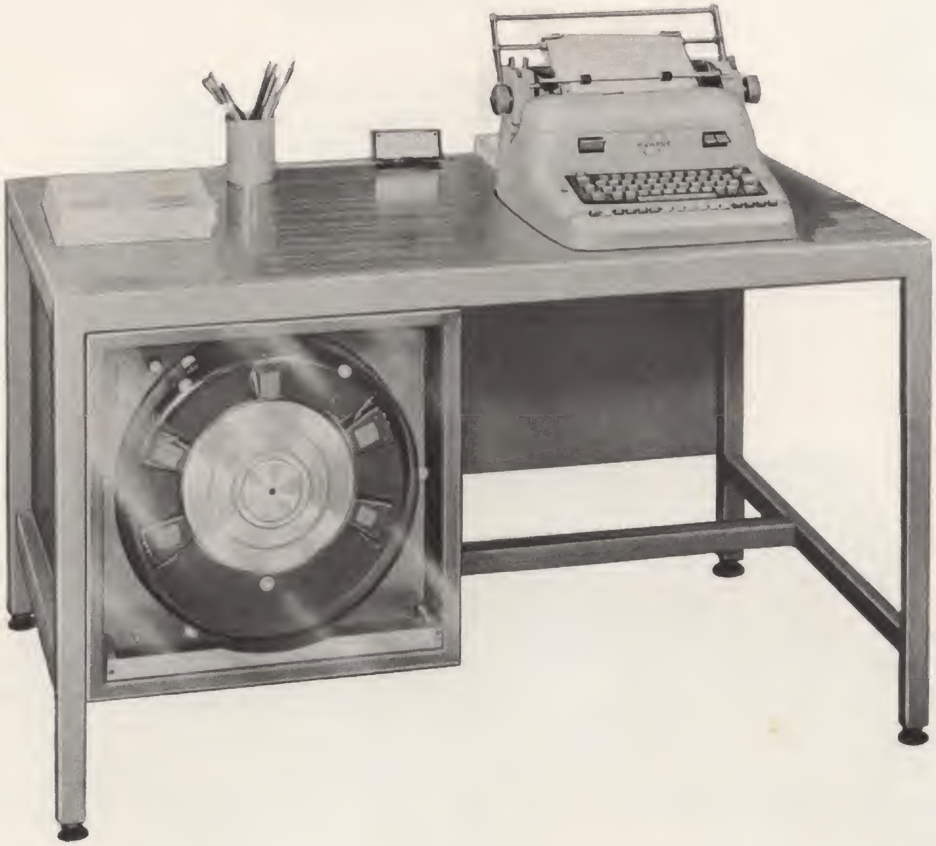


SYNCHRO TAPE PUNCH
MODEL 410-11-011P

ACCOUNTING MACHINES
PRESIDENT SERIES MODEL 466B803

SYNCHRO-PRESIDENT

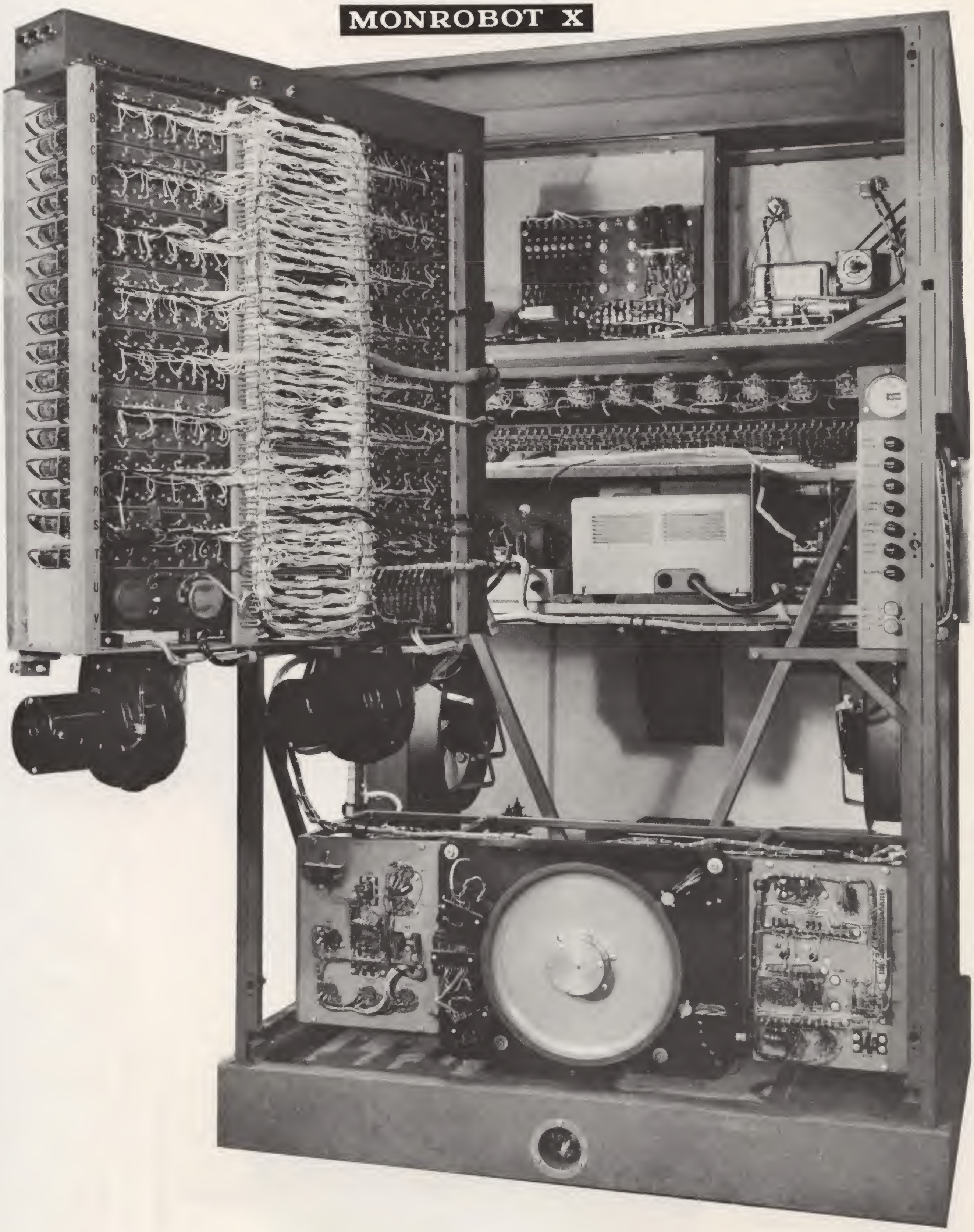
ELECTRONIC INVOICING MACHINE
MONROBOT IX



CARD TABULATOR
MODEL T81-111V11

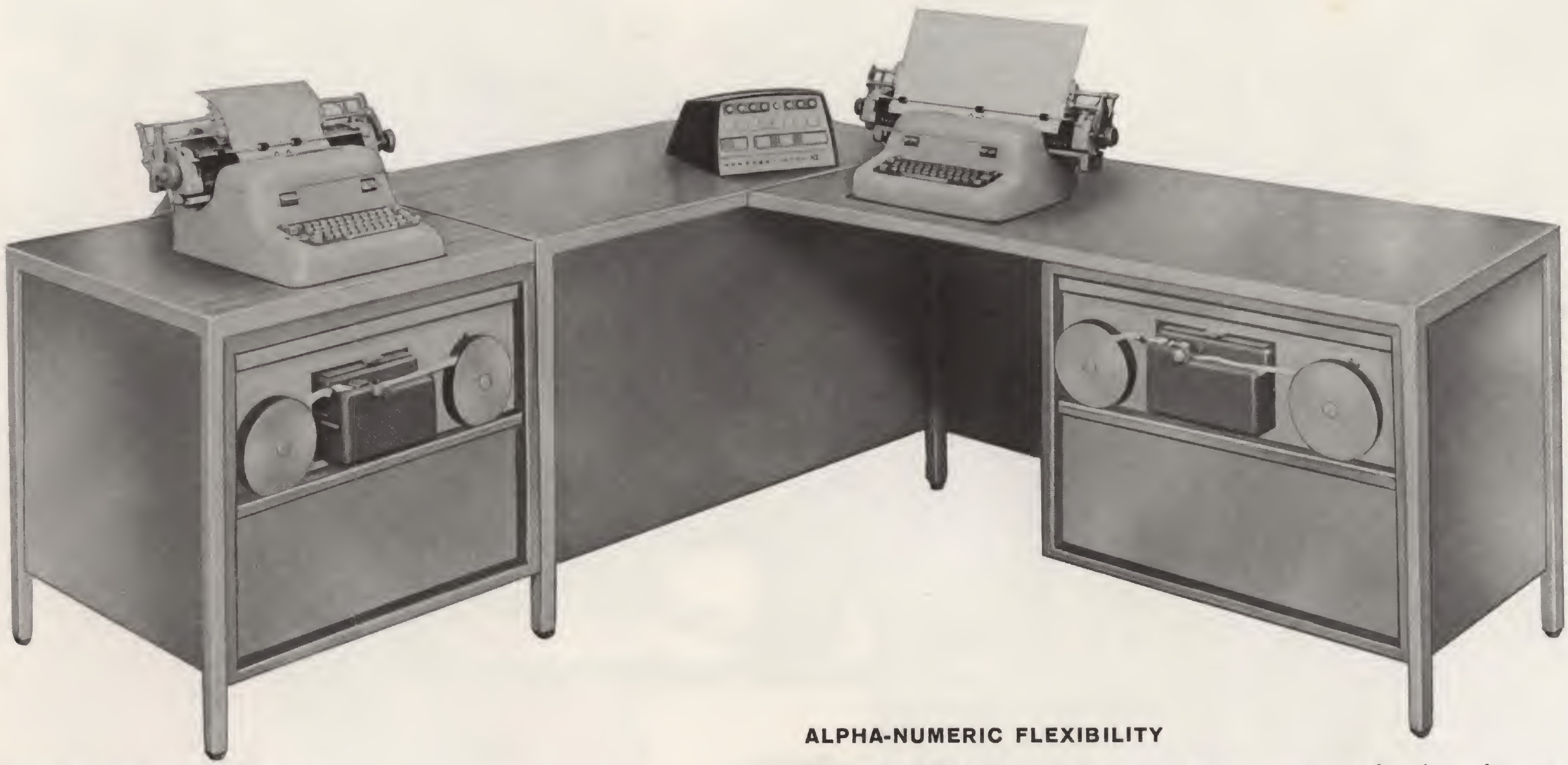
DISTRIBUTAPE COMPUTER

MONROBOT X



A Serviceman's view of the DISTRIBUTAPE, an electronic digital computer. It is designed to sort and summarize, at high speed, random information which has been recorded in the medium of punched paper tape. It will sort and summarize up to 999 different classifications in one processing run at an average rate of over 1000 transactions per minute.

WITH ADDITIONAL INPUT-OUTPUT DEVICES



SOLID-STATE DEPENDABILITY

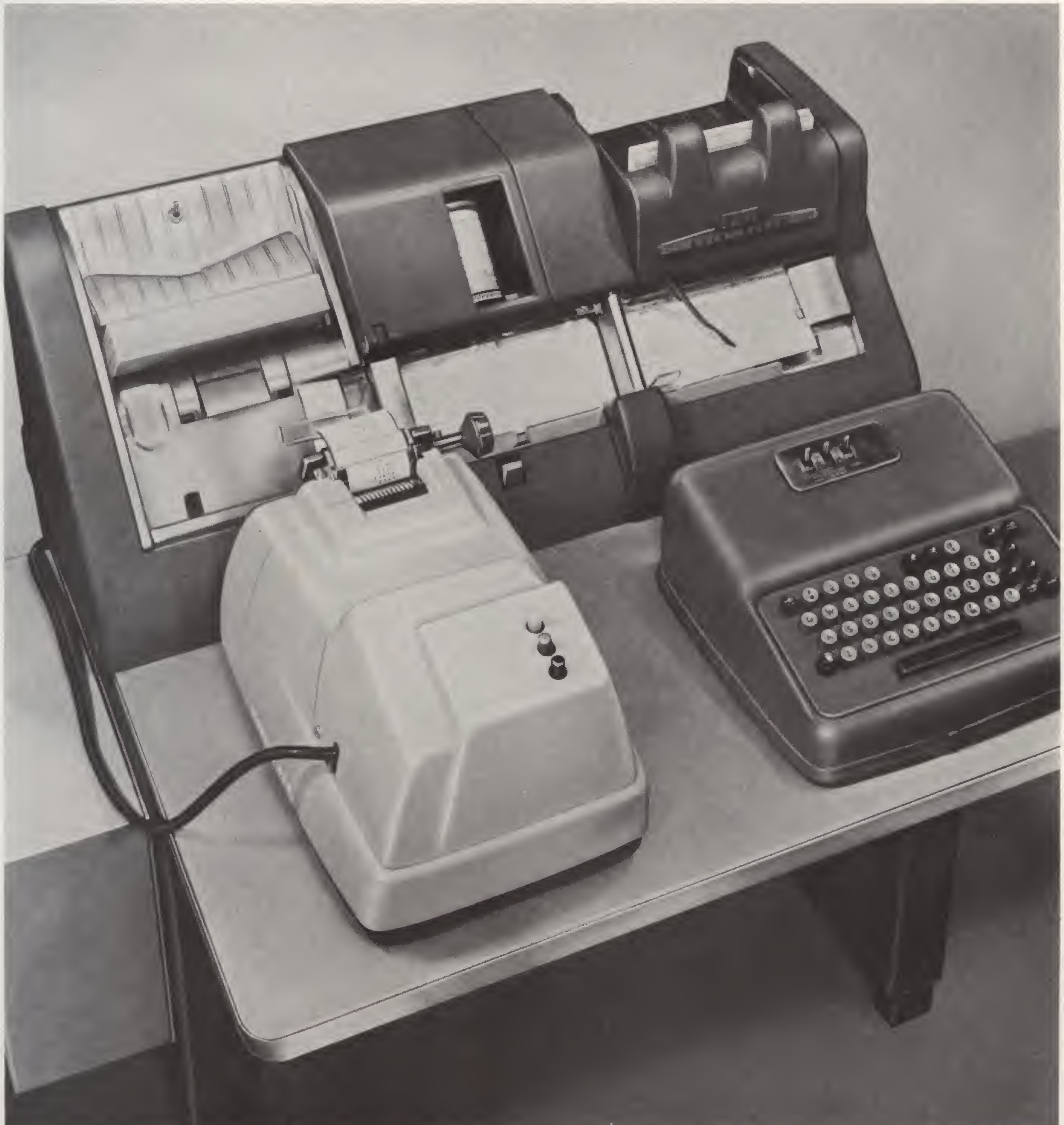
The "brain" of the Monrobot computer is a solid state logic unit which is controlled by as many as 2,000 instructions stored on a magnetic drum. Instructions such as add, subtract and compare are located and executed at an average rate of 12 milliseconds each . . . including access time. The logic unit simultaneously translates, verifies and edits alpha-numeric data from independent input devices. It requires no carriage or plugboard programming, plugboard format control, and tape language-translating equipment. It eliminates the myriad of control buttons, selection keys, interlock mechanisms and checking devices associated with such machines.

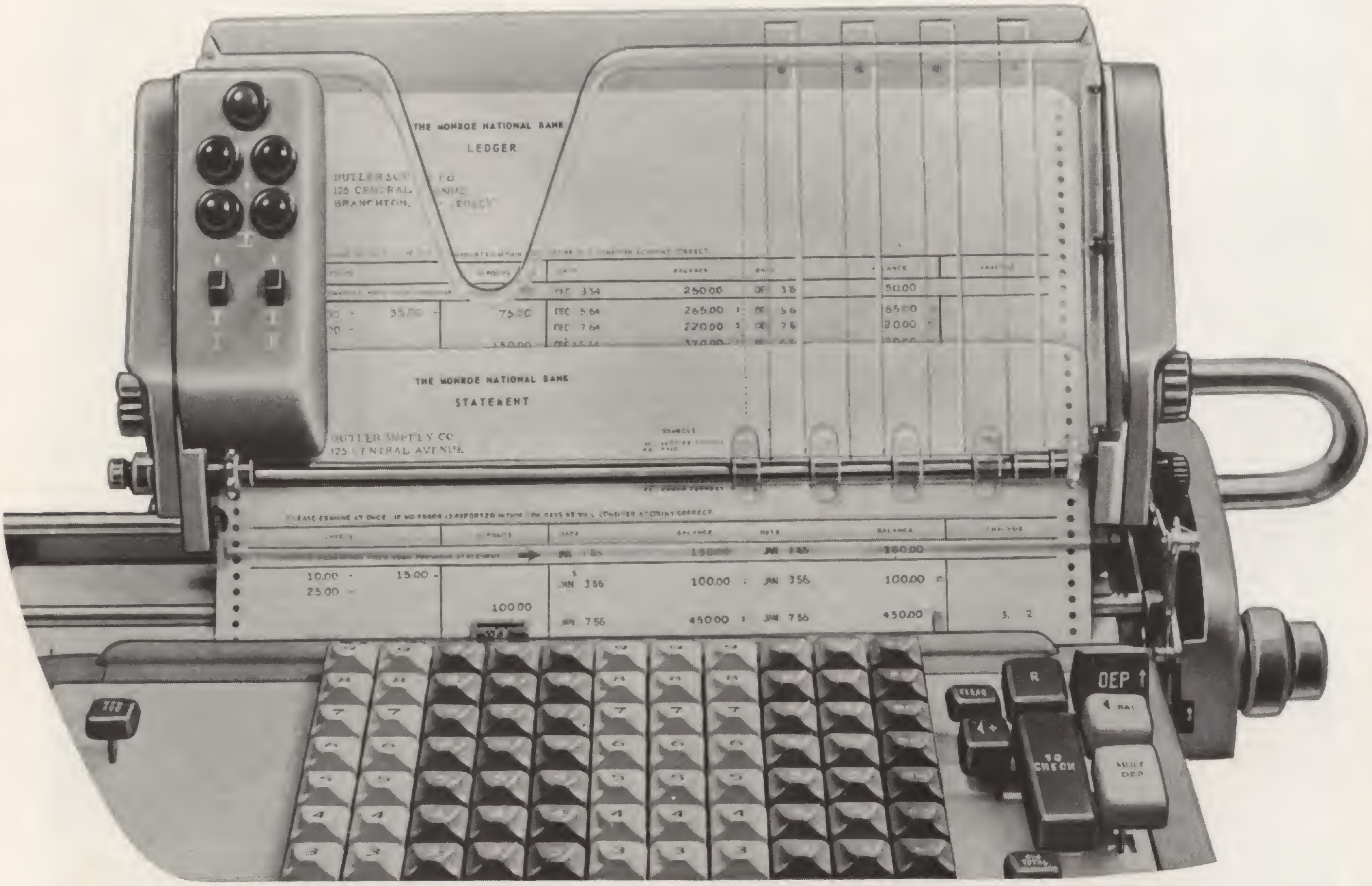
ALPHA-NUMERIC FLEXIBILITY

Monrobot XI will handle any number base — hours, fractions, dozens, pounds, yards, gross; it will convert francs, pounds, shillings, pence or other denomination to the equivalent in American currency. Not only does the machine understand varied alphabetic and numerical input data, but it will output in a variety of ways depending on the requirements of the job being done. Dates can be written in numerical or alphabetic form, departments spelled out or coded by number, amounts printed as decimal figures or completely written out in alphabetic letters. In short, data can be stored in memory in one form and written out on documents, tape or card in another.

DATA/LOG PRINTER
MC-205

DATA/LOG PRINTER
MC-215




THE MONROE NATIONAL BANK
LEDGER
THE MONROE NATIONAL BANK
STATEMENT
DEP
TO CHECK

Section 'H'

Section 'H' which follows, pertains directly to the specific information required for initial schooling on electro-mechanical products such as Synchro-Monroe machines.

A good understanding of section 'H' will equip you with required fundamental electrical data, in advance of enrollment in a Factory or Division school and result in your schooling being more enjoyable and profitable. This prior study could possibly reduce the length of the Orange or Division schooling period. This section will be continually referred to throughout the entire training period at Synchro-Monroe Schools.

With this basic schooling as a foundation, you may later advance into training courses on other electro-mechanical or electronic products shown in the photographs on adjoining pages.

If questions remain in your mind after study of this section, it would be mutually advantageous to discuss them with a member of your service department who has had Synchro machine training or television or radio repair experience.

DETAILS

VOLTAGE (V) The potential of the electromotive force (e.m.f.) that causes a large current to flow is usually furnished by an electric generator. The generated e.m.f. is either D.C. or A.C.

The unit e.m.f. is called Volt (V). The volt is defined as the e.m.f. that is necessary to cause one ampere of current to flow thru a resistance of one ohm.

CURRENT (I) The flow of electric current is measured in amperes (I).

Definition of ampere: One ampere is equivalent to the passage of one coulomb of electrons charge past a point in the circuit in one second.

Note: The coulomb is the unit used for measuring electric charges and represents approximately 6.28 million, million, million electrons.

RESISTANCE (R) A resistor may be defined as an electric component which offers resistance to the flow of current. It may be a coil of wire or a composition rod. The two types of fixed resistors generally used are referred to as wire-wound and carbon resistors.

The wire-wound resistor consists of a wire wound around a supporting base and then covered with an insulating material.

The carbon resistor is usually made of Carbon or Graphite. Due to the high resistance properties of Carbon and Graphite these resistors can be small in size and still have a high resistance value.

Carbon resistors are usually color coded according to Radio Manufacturers Association (R.M.A.) Standards.

The unit for measuring resistance is the OHM Ω.

The OHM is defined as the basic unit of electrical resistance equivalent to the resistance by which a current of one ampere can be maintained with a potential of one volt.

<u>WATT</u> A Watt is the unit of electrical power or rate of expending electrical energy. The watt is equal to one volt multiplied by one ampere. The abbreviation is W. or P.

Whenever current passes thru a resistor, heat is generated. This heat must be dissipated as fast as it is generated to allow the resistor to operate as a steady current. Resistors are rated to dissipate (or carry safely) a certain amount of Watts, or fraction of a Watt. <u>Whenever</u> replacing a resistor always replace the resistor with the same Wattage rating or higher, <u>never lower</u>.

In a circuit the values of the Voltage (e.m.f.) current and resistance are related. This relationship is known as <u>OHM'S LAW</u>. Ohm's law is usually stated as: The current (I) in a circuit is directly proportional to the applied voltage (e.m.f.) and inversely proportional to the Resistance (R).

<u>Expressed as an equation:</u>

$$I\ (\text{Amperes}) = \frac{E\ (\text{Volts})}{R\ (\text{Ohms})}$$

OHM's LAW FORMULA D.C.

E(Volts)	IR				$\frac{W}{I}$	$\sqrt{WR}$
I(Amperes)			$\frac{E}{R}$	$\frac{W}{E}$		$\sqrt{\frac{W}{R}}$
R(Ohms)		$\frac{E}{I}$		$\frac{E^2}{W}$	$\frac{W}{I^2}$	
W(Watts)	I^2R	EI	$\frac{E^2}{R}$			

THE DELTA FORMULA

The Delta Formula can be used for a quick reference of the relationship between Resistance, Voltage and Current. The formula is used by covering the factor not known, the remaining factors being either divided or multiplied, depending on the sign.

EXAMPLE: If current (I-Amperes) is not known; Cover (I). (I) can be found by dividing (R ohms) into E (Volts).

DETAILS

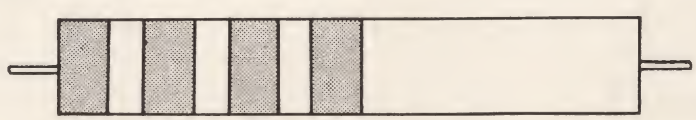
Carbon resistors are usually color coded according to Radio Manufacturer Association (R.M.A.) standards.

RESISTOR COLOR CHART

COLOR	1ST BAND 1ST FIGURE	2ND BAND 2ND FIGURE	3RD BAND MULTIPLIER	4TH BAND TOLERANCE ±
Black		0	None	
Brown	1	1	0	
Red	2	2	00	
Orange	3	3	000	
Yellow	4	4	0000	
Green	5	5	00000	
Blue	6	6	000000	
Purple	7	7	0000000	
Gray	8	8		
White	9	9		
Gold			.01	5%
Silver			.1	10%
No. 4th Band				20%

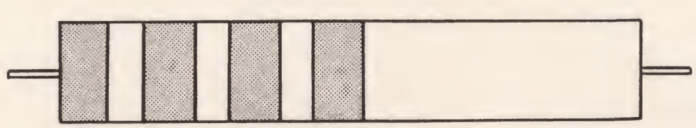
EXAMPLES: RESISTORS COLOR CODED

A



2 4 0 ± 5%
RED YELLOW BROWN GOLD

B



8 5 NONE ± 10%
GRAY GREEN BLACK SILVER

VALUE OF RESISTOR A IS 240 OHMS ± 5%

VALUE OF RESISTOR B IS 85 OHMS ± 10%

CAPACITORS (Condensers) A capacitor is two or more conductors seperated by a non-conductor or dielectric.

Fixed condensers are usually constructed from plates of metal foil with a thin solid or liquid dielectric between them. The solid dielectrics generally used are paper, special ceramics and mica. Mineral oil is generally used as a liquid dielectric. With this type of condenser it is not necessary to observe polarity.

The electrolytic capacitors are constructed of aluminum foil plates with semi-liquid conducting chemicals between them. When a D. C. voltage is applied to the capacitor an electro-chemical action takes place forming a very thin dielectric on one of the plates. NOTE: Polarity must be observed when replacing an electrolytic capacitor.

The unit of capacitance is the farad. The farad is much too large for practical work, therefore capacitance is usually measured in micro farads or micro-micro farads. One micro farad is one millionth of a farad, and a micro-micro farad is one millionth, millionth of a farad.

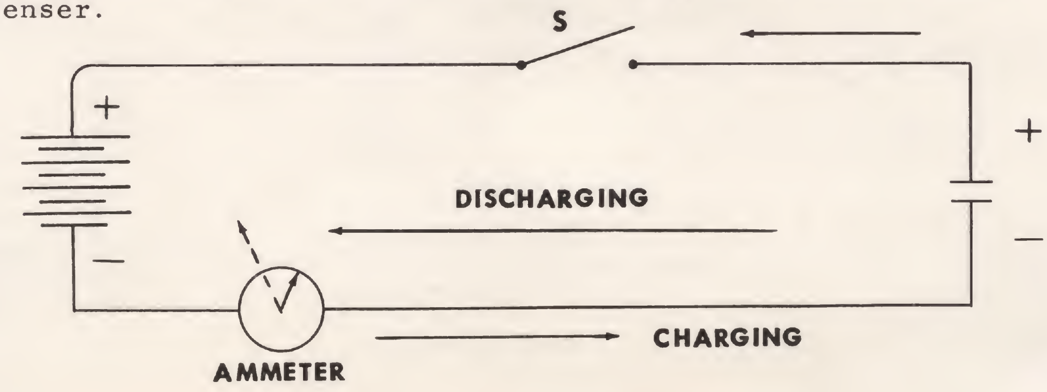
A micro farad is abbreviated MFD or ufd, and a micro-micro farad is abbreviated MMFD or uufd.

Condensers may be connected in series to enable the group to withstand a larger voltage than what the individual condenser is rated for. The voltage will divide equally as long as the condensers are of the same value. However, it should be remembered, when condensers are connected in series the total capacitance will be decreased.

Condensers are connected in parallel to obtain a larger total capacitance than is available in one unit. With condensers in parallel the largest voltage applied cannot exceed that of the condenser having the lowest voltage rating.

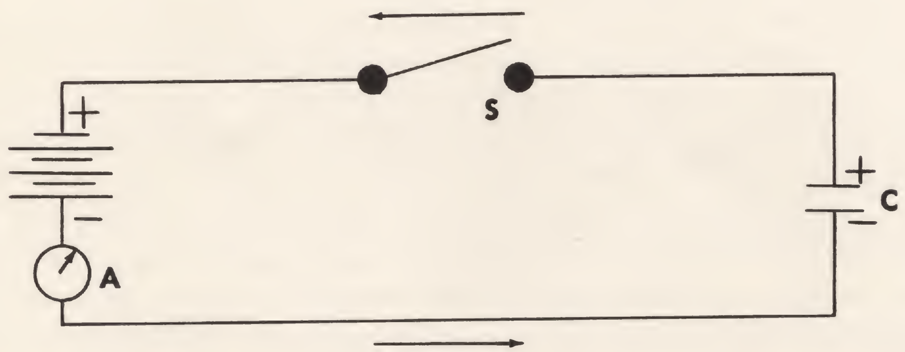
VOLTAGE BREAKDOWN OF A CONDENSER

When high enough voltage is applied to the plate of a condenser a large force is exerted on the electrons and much of the dielectrics. If the force exerted on the dielectric is great enough the dielectric will puncture and allow current to flow. The voltage at which the condenser will be damaged (and allow current to flow) is known as the breakdown voltage. Therefore, condensers are not only rated for their unit of capacity but also for their D.C. working voltage. This working voltage is the maximum D.C. voltage which may be steadily applied (without harm) to the condenser.



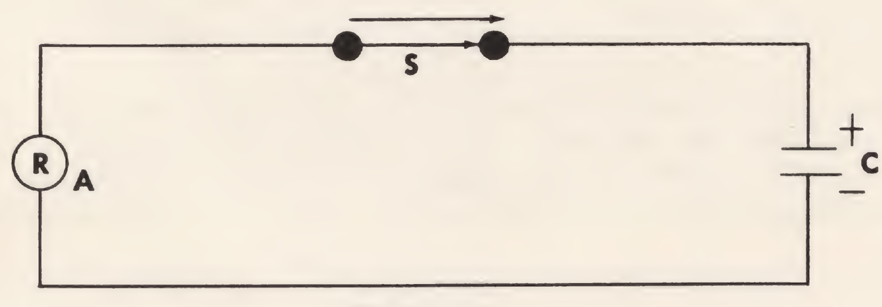
DETAILS

(1) When switch "S" is closed, the capacitor will charge instantly (theoretically) to the voltage of the battery. The ammeter will show only a momentary flow of current while the capacitor is charging. The capacitor is now charged and current will cease to flow in the circuit.

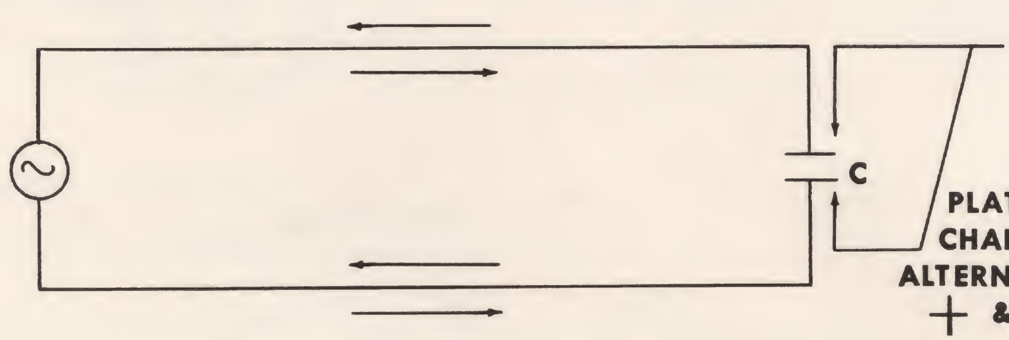


(2) If the battery is now removed from the circuit the ammeter will show another momentary flow of current, but in the opposite direction than that of figure (1).

The capacitor is now discharged.



(3) When an A.C. voltage is applied to a capacitor the current flowing thru the external circuit is charging and discharging the capacitor in one direction, an instant later it is charging and discharging the capacitor in the other direction. It can be seen that it is possible to have a continuous flow of current in the external circuit without going thru the capacitor from one plate to the other.



RESISTOR SERIES AND PARALLEL CIRCUITS

The two fundamental methods of connecting resistors is in series or parallel.

SERIES CIRCUITS

A Series Circuit consists of two or more resistors connected in series so that current will pass from one resistor to the next until the path is complete.

In a series circuit:

The total resistance is equal to the sum of the resistors.

$$(R_T = r_1 + r_2 + r_3 \text{ etc.}) \qquad (1\text{-}1)$$

The applied voltage (e.m.f.) is equal to the sum of the voltage drop across each resistor.

$$(E_T = e_1 + e_2 + e_3 \text{ etc.}) \qquad (1\text{-}2)$$

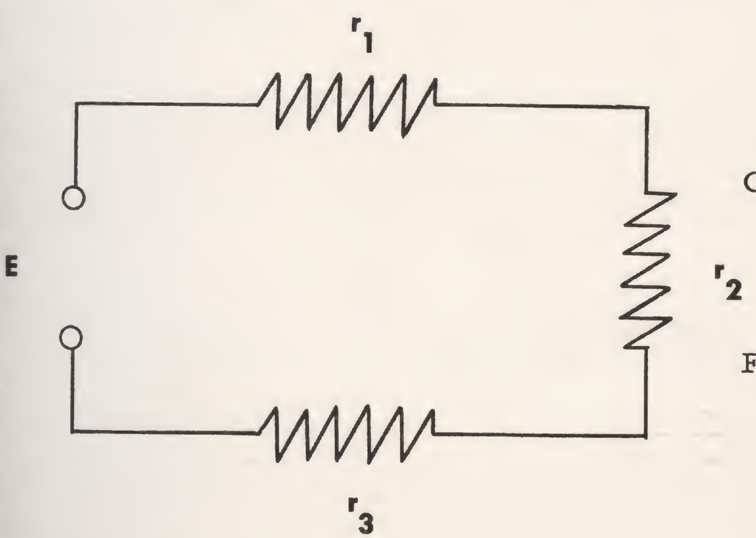
The current is equal everywhere in the circuit.

$$(I_T = i_1 = i_2 = i_3 \text{ etc.}) \qquad (1\text{-}3)$$

The total wattage (power) is equal to the sum of the wattage (power) of each resistor.

$$(P_T = P_1 + P_2 + P_3 \text{ etc.}) \qquad (1\text{-}4)$$

Problem of resistor in series and solution:



Given: $E = 100V$
$r_1 = 20$
$r_2 = 20$
$r_3 = 10$

Find: R_T
I

Problem:
Find voltage drop across,
r_1, r_2, r_3,
P_1, P_2, P_3,
P_T

RESISTORS IN SERIES
SOLUTION

To solve for R_T use formula 1 - 1

$$R_T = r_1 \ \ r_2 \ \ r_3$$

$$R_T = 20 \ \ 20 \ \ 10$$

$$R_T = 50$$

To solve for I use Ohms Formula:

$$I = \frac{E}{R}$$

$$I = \frac{100}{50}$$

$$I = 2 \text{ amp.}$$

To find the voltage drop across r_1, r_2, r_3, use Ohms Formula

$$E = I \times R$$

Solving for the voltage drop across e_1

$$e_1 = i_1 \times r_1$$

$$e_1 = 2 \times 20$$

$$e_1 = 40V$$

Voltage drop across e_2

$$e_2 = i_2 \times r_2$$

$$e_2 = 2 \times 20$$

$$e_2 = 40V$$

Voltage drop across e_3

$$e_3 = i_3 \times r_3$$

$$e_3 = 2 \times 10$$

$$e_3 = 20V$$

The sum of the voltage drops must equal the applied voltage, therefore using formula 1 - 2

$$e_1 \ \ e_2 \ \ e_3 = E$$

$$40 \ \ 40 \ \ 20 = 100$$

$$100 = 100$$

To solve for p_1, p_2, p_3, use Ohms Formula $P = E \times I$.

$$p_1 = e_1 \times i_1$$

$$p_1 = 40 \times 2$$

$$p_1 = 80W$$

Solving for p_2

$$p_2 = e_2 \times i_2$$

$$p_2 = 40 \times 2$$

$$p_2 = 80W$$

Solving for p_3

$$p_3 = e_3 \times i_3$$

$$p_3 = 20 \times 2$$

$$p_3 = 40W$$

To find the total wattage use formula 1 - 4

$$P = p_1 + p_2 + p_3$$

$$P = 80 + 80 + 40$$

$$P = 200W$$

The total wattage of this circuit may also be found by using Ohms Formula $P = E \times I$

$$P = E \times I$$

$$P = 100 \times 2$$

$$P = 200W$$

PARALLEL CIRCUITS

A parallel circuit consists of two or more resistors connected in parallel so that the current has two or more paths to follow.

In a parallel circuit:

The total resistance is less than the lowest resistor in the circuit.

$$R_T = \frac{1}{\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}} \text{ etc.} \qquad (2 - 1)$$

(When only two resistors are in parallel in a circuit the formula used is

$$R_T = \frac{r_1 \times r_2}{r_1 + r_2} \qquad (2 - 2)$$

(With three or more resistors in parallel a more practical method of solving for R_T, is to first solve for I_T and then use Ohms Law

$$R = \frac{E}{I} \qquad (2 - 3)$$

The applied voltage (e.m.f.) is applied to all resistors.

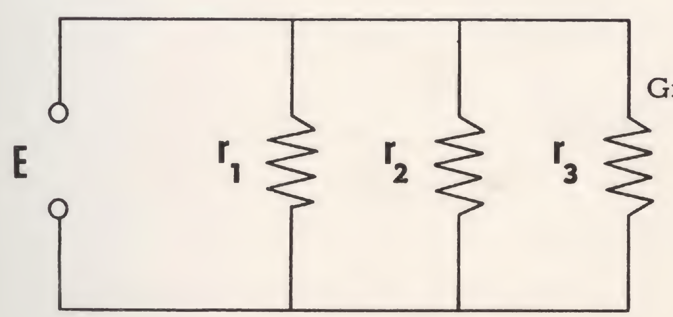
$$E_T = e_1 = e_2 = e_3 \text{ etc.} \qquad (2 - 4)$$

The total current is equal to the sum of the current of each resistor.

$$I_T = i_1 + i_2 + i_3 \text{ etc.} \qquad (2 - 5)$$

The total wattage (power) is equal to the sum of the wattage of each resistor.

Example resistors in parallel. (2 - 6)



Given: $E = 100V$
$r_1 = 10$
$r_2 = 10$
$r_3 = 20$

Problem:
Find voltage drop across, R_T, i_1, i_2, i_3, I_T and P_T

DETAILS

PARALLEL CIRCUITS
SOLUTION

To find R_T first solve for I_T. (Formula 2 - 3) (Ohms Law)

$$i_1 = \frac{E}{r_1}$$

$$i_1 = \frac{100}{10}$$

$$i_1 = 10 \text{ amp.}$$

$$i_2 = \frac{E}{r_2}$$

$$i_2 = \frac{100}{10}$$

$$i_2 = 10 \text{ amp.}$$

$$i_3 = \frac{E}{r_3}$$

$$i_3 = \frac{100}{20}$$

$$i_3 = 5 \text{ amp.}$$

$$I_T = i_1 = i_2 = i_3$$ (Formula 2-5)

$$I_T = 10 = 10 = 5$$

$$I_T = 25 \text{ amp.}$$

$$R = \frac{E}{I}$$

$$R = \frac{100}{25}$$

$$R = 4$$

$$P_T = E \times I$$ (Ohms Law)

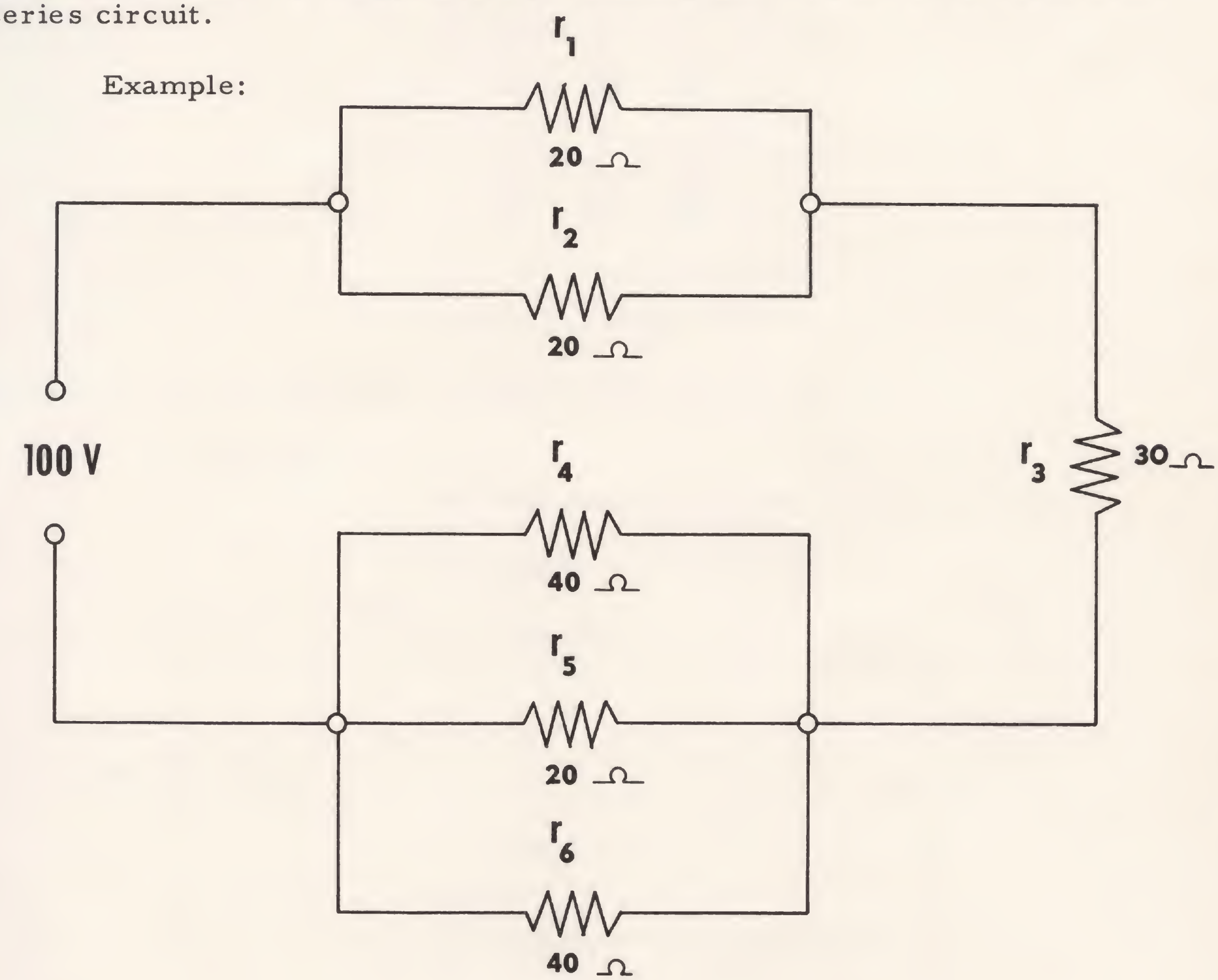
$$P_T = 100 \times 25$$

$$P_T = 2500 \text{ watts}$$

PROBLEM OF A SERIES - PARALLEL CIRCUIT AND SOLUTION

A series parallel circuit will employ resistors in series and in parallel. Its solution may be simplified by reducing the circuit to an equivalent series circuit.

Example:



First find the equivalent resistance of each parallel group.

Group 1

$$R_T = \frac{r_1 \times r_2}{r_1 + r_2} \qquad \text{(Formula 2 - 2)}$$

$$R_T = \frac{20 \times 20}{20 + 20}$$

$$R_T = \frac{400}{40}$$

$$R_T = 10\ \Omega$$

SERIES - PARALLEL CIRCUIT

Group 2 $$R_T = \frac{1}{\frac{1}{r_4} + \frac{1}{r_5} + \frac{1}{r_6}}$$ (Formula 2 - 1)

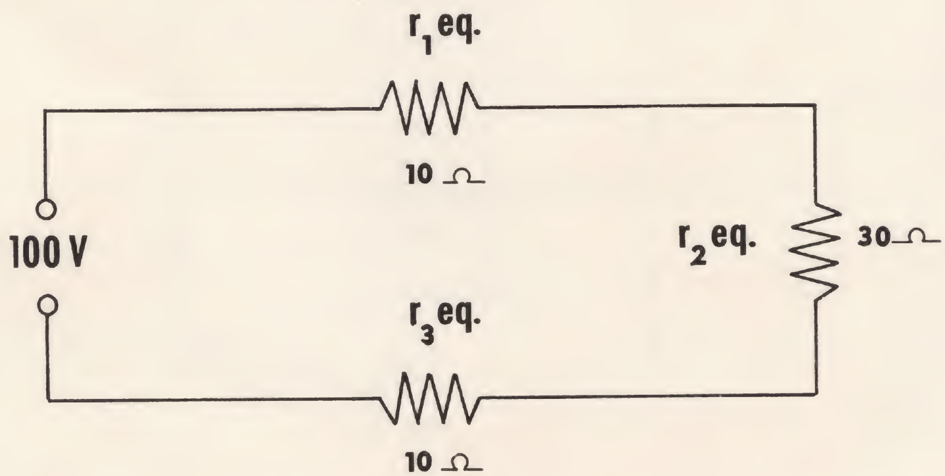
$$R_T = \frac{1}{\frac{1}{40} + \frac{1}{20} + \frac{1}{40}}$$

$$R_T = \frac{1}{\frac{1}{40} + \frac{2}{40} + \frac{1}{40}}$$

$$R_T = \frac{1}{\frac{4}{40}}$$

$$R_T = 10\ \Omega$$

The equivalent circuit may be shown as:



All values for the circuit may now be found by using the formulas previously discussed.

Solving for --

$$R_T = r_1 \text{ eq.}, + r_2\text{eq.} + r_3 \text{ eq.}$$ (Formula 1 - 1)

$$R_T = 10 + 30 + 10$$

$$R_T = 50$$

DETAILS

SERIES - PARALLEL CIRCUIT

$I = \frac{E}{R}$ (Ohms Law)

$I = \frac{100}{50}$

$I = 2$ amp.

$P = E \times I$ (Ohms Law)

$P = 100 \times 2$

$P = 200$ W

Solving for the voltage drop across r_1 eq., $r_2$eq. r_3 eq.

e_1 eq $= i \times r_1$ eq. (Ohms Law)

e_1 eq $= 2 \times 10$

e_1 eq $= 20V$

$e_2 = i \times r_2$

$e_2 = 2 \times 30$

$e_2 = 60V$

e_3 eq $= i \times r_3$ eq.

e_3 eq $= 2 \times 10$

e_3 eq $= 20V$

Finding the current flowing thru r_1, r_2, r_3, r_4, r_5, r_6.

$i_1 = \frac{eq_1}{r_1}$ (Ohms Law)

$i_1 = \frac{20}{20}$

$i_1 = 1$ amp.

DETAILS

SERIES - PARALLEL CIRCUIT

Finding P for r_1, r_2, r_3, r_4, r_5, r_6.

$i_2 = \frac{eq_2}{r_2}$

$i_2 = \frac{20}{20}$

$i_2 = 1$ amp.

$i_3 = \frac{eq_3}{r_3}$

$i_3 = \frac{60}{30}$

$i_3 = 2$ amp.

$i_4 = \frac{eq_4}{r_4}$

$i_4 = \frac{20}{40}$

$i_4 = .5$ amp.

$i_5 = \frac{eq_5}{r_5}$

$i_5 = \frac{20}{20}$

$i_5 = 1$ amp.

$i_6 = \frac{e_6}{r_6}$

$i_6 = \frac{20}{40}$

$i_6 = .5$ amp.

$p_1 = e_1 \times i_1$ (Ohms' Law)

$p_1 = 20 \times 1$

$p_1 = 20W$

$p_2 = e_2 \times i_2$

$p_2 = 20 \times 1$

$p_2 = 20W$

$p_3 = e_3 \times i_3$

$p_3 = 60 \times 2$

$p_3 = 120W$

$p_4 = e_4 \times i_4$

$p_4 = 20 \times .5$

$p_4 = 10W$

$p_5 = e_5 \times i_5$

$p_5 = 20 \times 1$

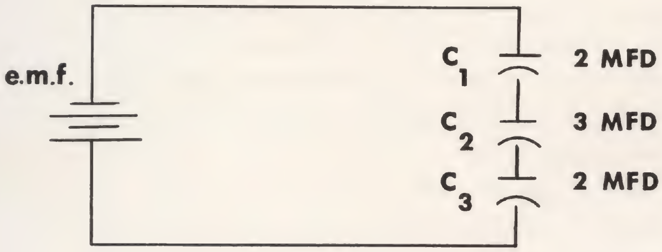
$p_5 = 20W$

$p_6 = e_6 \times i_6$

$p_6 = 20 \times .5$

$p_6 = 10W$

FORMULA FOR CAPACITORS SERIES AND PARALLEL



Series (Three or More)

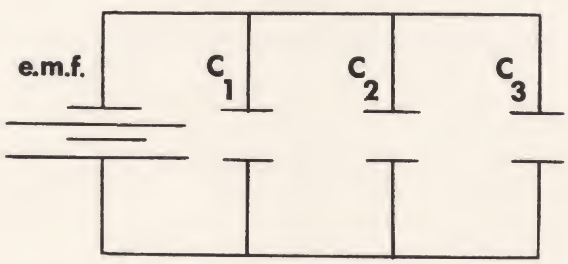
$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

$$C_T = \frac{1}{\frac{1}{2} + \frac{1}{3} + \frac{1}{2}} = \frac{1}{\frac{8}{6}} = .75 \text{ M.F.D.}$$

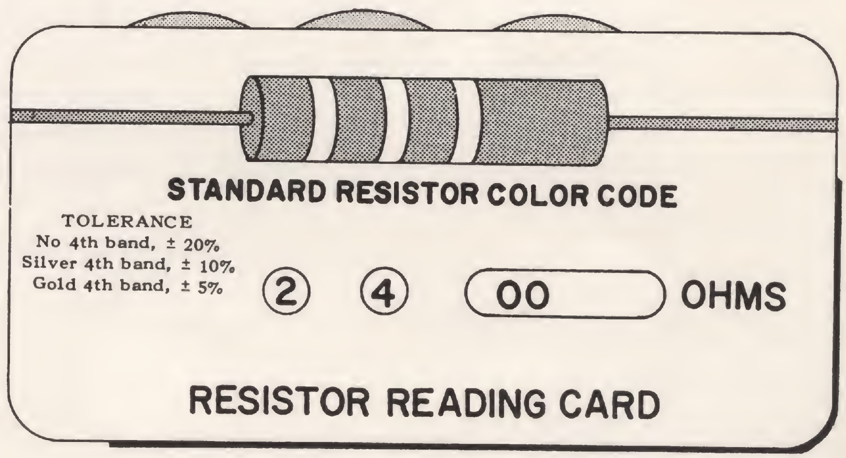
for two in series use $\frac{C_1 \times C_2}{C_1 + C_2}$

for parallel circuit $C_T = C_1 + C_2 + C_3$ etc.

PARALLEL CIRCUIT



Special tools, gauges, meters, scopes etc. are required for servicing Monroe Electro-mechanical and electronic products. Shown here is a resistor reading card with which the bands (stripes) around a resistor can be read quickly and accurately. The bands on resistors can be black, white, brown, red, orange, yellow, green, blue, purple or gray. To decode, or read a resistor, rotate the cardboard dials on your reader until the colors in each of the three bands match the color bands on the actual resistor.



ELECTROMAGNETISM & INDUCTANCE

Whenever current passes thru a wire a magnetic field is produced. If the wire were to be wound in a coil the magnetic field would be greatly increased, also if the current thru the coil were to be increased the magnetic field would increase. Therefore, the magnetomotive force is equal to Ix number of turns. (MMF = I x T.)

When a bar of iron or some other magnetic substance is placed in a coil of wire, the iron will become magnetized when the current flows, thus forming an electromagnet. The magnetic core will then greatly strengthen the magnetic field.

The solenoids and relays used in the Monroe Punch & Chassis employ electromagnets.

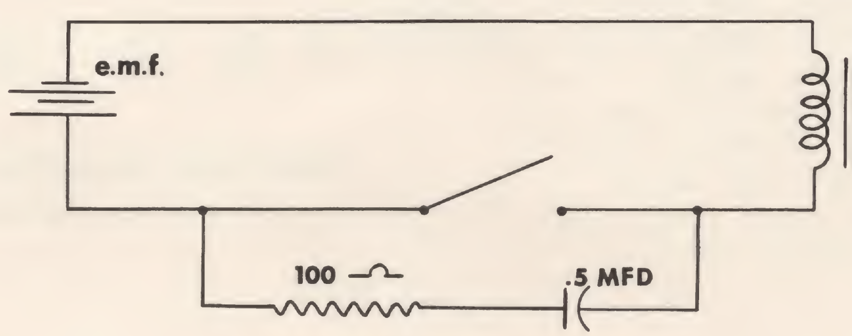
INDUCTANCE is the property of a current to oppose any change in the current flowing in the circuit. When the current in the circuit is being increased the induced e.m.f. will be in a direction opposite the applied voltage.

The unit for Inductance is the henry and the symbol used is "L".

The formula for total inductance in series is $L_T = L_1 + L_2 + L_3$ etc.

In parallel $L = \dfrac{L_1 \times L_2}{L_1 + L_2}$ or $\dfrac{1}{\dfrac{1}{L_1} + \dfrac{1}{L_2} + \dfrac{1}{L_3}}$

In an Inductive circuit, if a switch is opened, the energy stored in the magnetic field would return to the circuit instantly. The rapid disapperance of the field causes a large voltage to be induced in the coil many times larger than the applied voltage. A common result of opening the switch is that an arc forms and possibly burns or melts the contacts. Therefore, whenever a switch or contact is to be open in an inductive circuit it is necessary to have a "spark suppression circuit" to prevent damage to the switch or contacts.



SPARK SUPPRESSION CIRCUIT

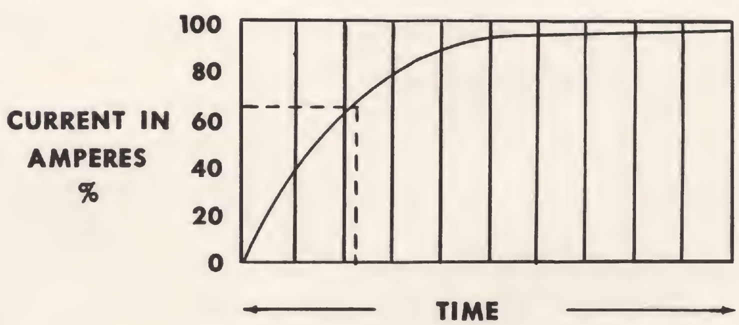
TIME CONSTANT (R-L CIRCUIT)

An inductor may be considered as an inductor and resistor in series (a coil has resistance). If a circuit has any resistance in it the current will rise to its OHM law value almost instantaneously. However, if an inductor is in series with a resistor the current will require more time to reach its OHM law value (than with only resistance). This is due to the fact that the current must pass from a lesser value to its final value. This amount of changing current will induce an e.m.f. in the inductor which will oppose the applied voltage preventing the current from reaching its OHMs law value. The current, however, will reach its OHMs law value due to the resistance in the circuit. The current will increase exponentially as shown in the Graph and will rise to 63% (this figure is chosen for mathematical reasons) of its final value in a period of time equal to the inductance of the circuit divided by the resistance of the circuit. Therefore, the time constant of an R-L Circuit is $t = \frac{L}{R}$

EXAMPLE A relay has an inductance of 2.4 henries*, a resistance of 12 OHMs. The relay closes when the current reaches 63% of its final value. What is the time interval of closing of the relay?

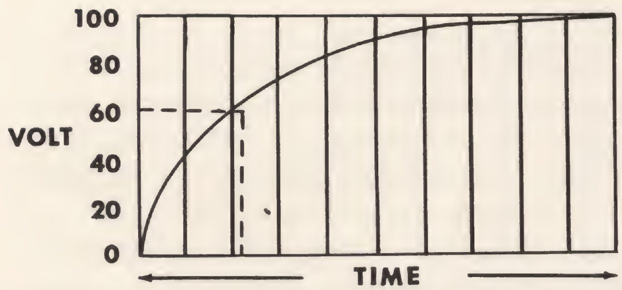
t = time in seconds
L = inductance in henries
R = resistance in OHMs

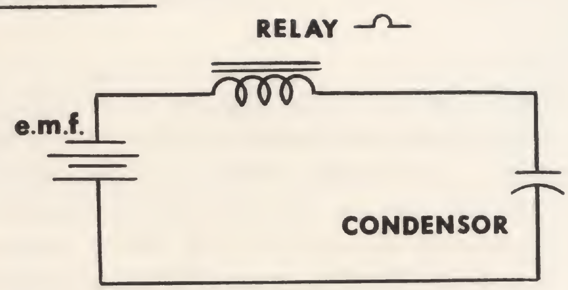
$$t = \frac{L}{R} = \frac{2.4}{12} = .2 \text{ sec.}$$



*HENRY: *Named after Joseph Henry - The practical unit of Electromagnetic or Magnetic Induction, or the induction in a circuit in which the electromotive force (e.m.f.) is one volt, the inducing current varying at the rate of one ampere per second.*

R.C. TIME CONSTANT





Rate of voltage rise is a function of the product of the resistance and the capacity 99% of volt max. in 5RC. 63% of volt max. in 1. RC.

R. C. TIME CONSTANT The time required to charge a condensor is a function of R $\times$ C.

R. C. time = time in seconds for a condensor to reach 63% of OHM value.

R = resistance in OHMs
C = capacity in farands (one farad = 1,000,000 M.F.D.)

given R = 1,000 Ω

given C = 2 M.F.D.

therefore time $= 1,000 \times \frac{2}{1,000.000} = .002$ sec.

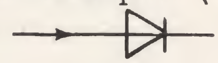
one farad $= 1 \times 10^{-6}$ or 1. uf. or $\frac{1}{10^{-6}} = \frac{1}{1,000.000}$

POWER SUPPLY

The current supplied to the components of the Tape Punch Units must be a direct non-pulsing current. Therefore, if the line (or input) voltage is A.C. it is necessary to convert the A.C. to D.C. This conversion is known as rectification and is accomplished through the use of a metallic and crystal rectifier. The crystal type of rectifier is usually referred to as a diode and is identified by the symbol . The metallic rectifier is usually referred to as a selenium rectifier (as the material used in these rectifiers is selenium) and is identified by the symbol .

A characteristic of a rectifier or diode is that it will offer a high resistance to current flowing in one direction while offering very little resistance to the current flowing in the opposite direction.

A bridge type rectifier circuit is used to produce full wave rectification. This full wave rectification will be a pulsating D.C. (This pulsating can be eliminated through the use of a filter circuit.)

To facilitate the explanation of a bridge type rectifier, the conventional flow of current will be used. That is, current will flow from plus (+) to minus (-) or in the direction of the rectifier symbol  .

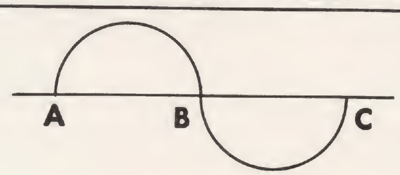
At the instant point A (Fig. 1) is conducting, current will flow in the direction of the dotted arrows. The low forward resistance of rectifier R_2 will allow current to flow through it, through the load and then through rectifier R_3 to point B, (See Fig. 1). Current will not flow through rectifier R_1 and R_4 due to the high resistance presented in these rectifiers when A is conducting. The output signal will appear as half a wave point A-B (See Fig. 2).

On the next half of the cycle when B is conducting (point B to C., Fig. 1), current will flow in the direction of the solid arrows. Current will flow through the low forward resistance of rectifier R_4 , through the load then through rectifier R_1 to point C. Current will not flow through rectifiers R_2 and R_3 due to high resistance presented. The output signal will appear as the other half wave, point B to C. (See Fig. 2)

BRIDGE TYPE RECTIFIER CIRCUIT

INPUT SIGNAL A.C.

Fig. 1



OUTPUT SIGNAL D.C.

Fig 2

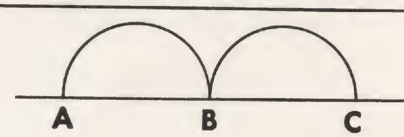
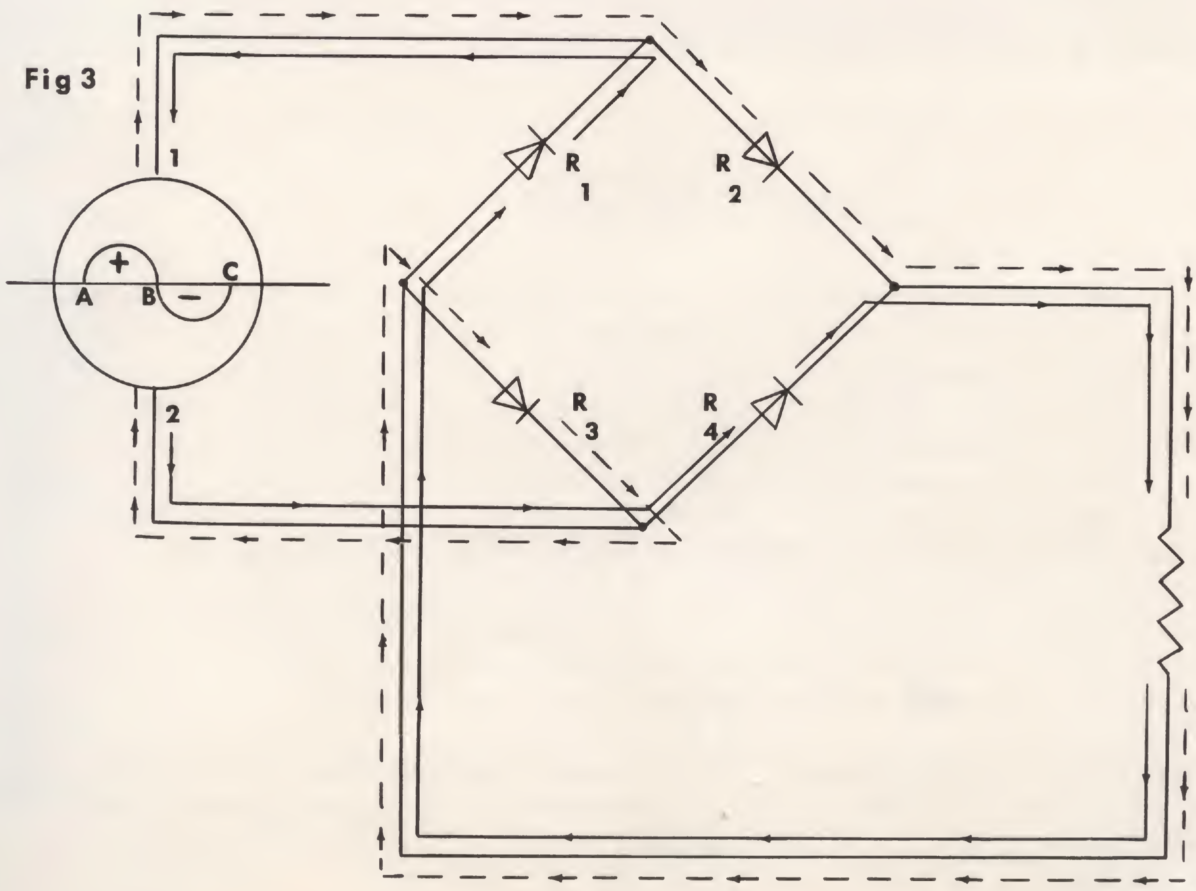


Fig 3



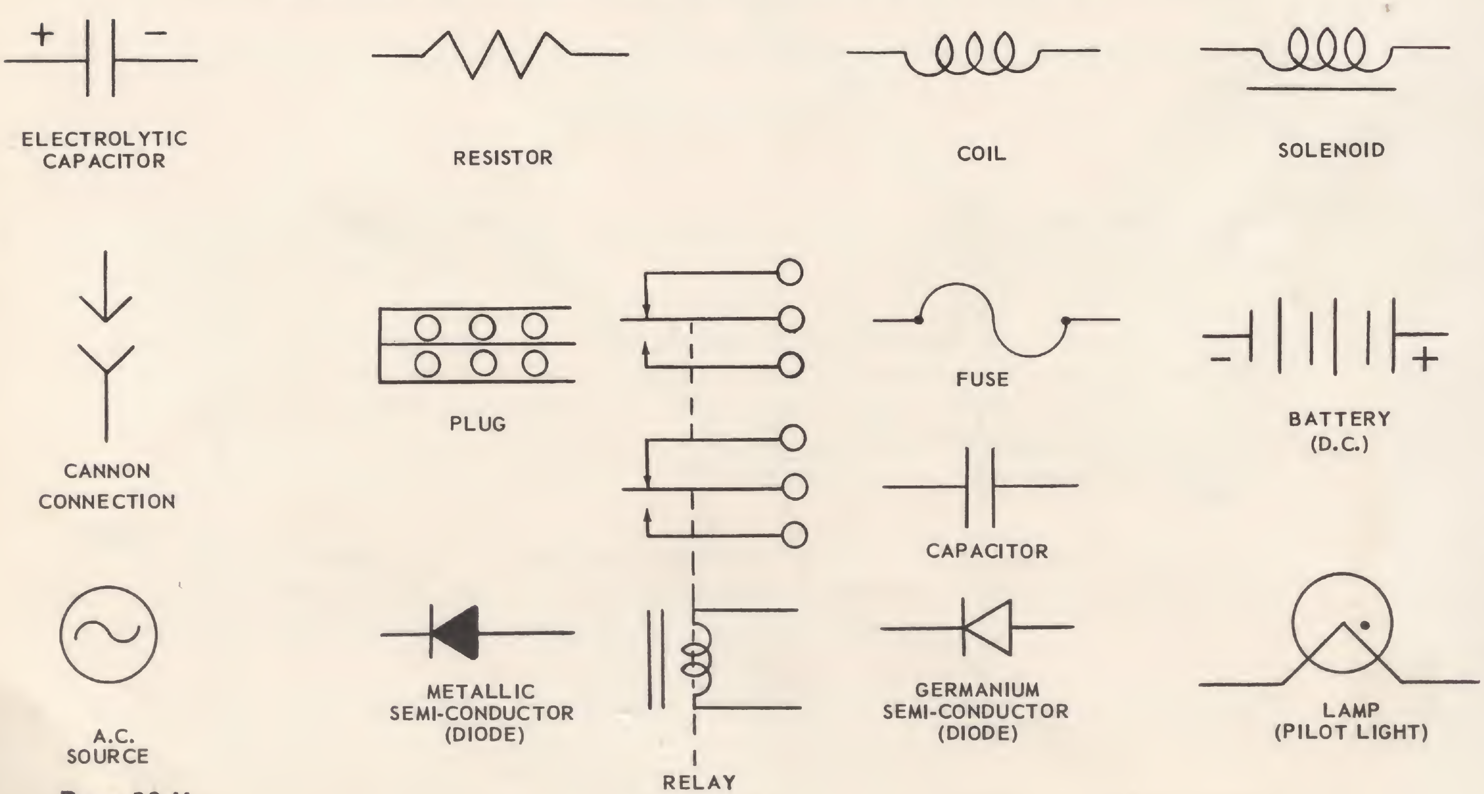
UNIT CONVERSION TABLE AND ELECTRICAL SYMBOL CHART

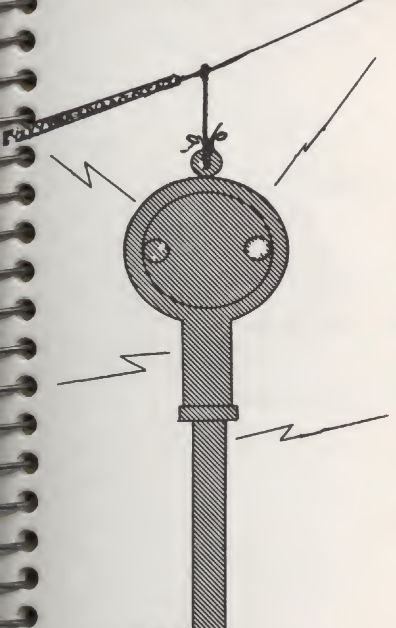
CONVERSION TABLE

This table can be used as a ready reference to convert units to micro-units etc.

TO-CHANGE-FROM	TO	MULTIPLY-BY	DIVIDE-BY
Units	Micro-Units	1,000,000	
Units	Milli-Units	1,000	
Units	Kilo-Units		1,000
Units	Mega-Units		1,000,000
Micro-Units	Milli-Units		1,000
Micro-Units	Units		1,000,000
Milli-Units	Micro-Units	1,000	
Milli-Units	Units		1,000
Kilo-Units	Mega-Units		1,000
Kilo-Units	Units	1,000	
Mega-Units	Kilo Units	1,000	
Mega-Units	Units	1,000,000	

Electrical Symbols used in Synchro-Monroe Equipment.





Fly A Kite

The key to knowledge of electricity, was Benjamin Franklin's kite, sent up into a thunderstorm to coax electric current from the storm, down the cotton string, to the silk rope he used as an insulator. (The kite was fixed with a thin wire attached to the framework of cedar strips.) Franklin's metal key gave off an electric spark when the cotton string became wet from the rain. Electricity from the key was so abundant that he was able to fill his leyden jar (storage battery) from it. He proved that lightning is electricity. Electricity, like uranium, oil and ore, has always been available in the universe but an understanding of its source and usage had to wait until man sought out and studied the actions of this mysterious force. We have much remaining to be learned and the study of electricity is challenging and unending. Your value to our Service Organization increases with your acquisition of knowledge, both mechanical and electrical.

Men whose names are now electrical bywords:-

FARADAY VOLTA AMPERE WATT HENRY

DEFINITIONS

Electricity is founded upon the theory of the ELECTRON.

The Electron is a part of an atom.

An Atom is the smallest physical particle into which an element can be divided.

Atoms are elements.

An element can be Oxygen, Hydrogen, Carbon, etc.

Elements are the makeup of molecules.

Molecules make up the human body of Carbon, Hydrogen, Oxygen, Nitrogen, Calcium, Phosphorus.

1. ATOM - Smallest physical particle into which an element can be divided.

2. MOLECULE - A combination of two or more atoms.

3. NUCLEUS - The Positive charged part of an Atom that does not move.

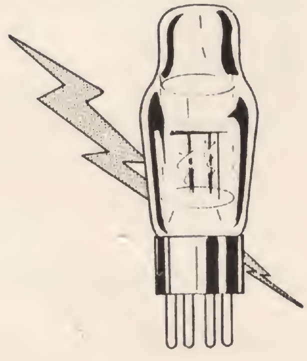
4. NEUTRON - A heavy neutral particle in the Nucleus made up of a proton and an Electron.

5. PROTON - A heavy positively charged particle in the nucleus.

6. ELECTRON - A very small negatively chargedparticle which is nearly weightless and circles the nucleus.

7. BOUND ELECTRONS - Electrons in the inner orbits of an atom, which cannot be easily forced out of their inner orbits.

8. FREE ELECTRONS - Electrons in the outer orbits, which can be easily forced out of their orbits.



DEFINITIONS

The nearer the Electron to the Nucleus, the harder to force the Electron from its orbit. Therefore, those in the outer orbits are more easily forced from these orbits than the Bound Electrons in the Inner Orbits.

Electric Current - It is the motion of the free electrons that makes up an electric current. The effect of these electrons in moving from point to point with too many or too few in a material causes an electric current.

Current Flow

The movement of "free electrons" flowing through a material, also determines the opposition to Current Flow. This is Resistance.

Sources of Electricity

Joining molecules together, (which are actually two or more atoms joined together) gives us a material. We have six basic sources of energy or materials which will generate electric charges ----

1. Friction
2. Pressure
3. Heat
4. Light
5. Magnetism
6. Chemical Action

Electric Charges

If we force an electron out of its orbit, the action will be known as electricity. When we force Electrons out of one material and into another material we would then have an excess of electrons in one material and a lack of electrons in another material. An excess of electrons would be a "Negative Charge" while a lack of electrons in a material would be a "Positive Charge."

Negative Charge

An excess of electrons in a material is a negative charge.

Positive Charge

A lack of electrons in a material is a positive charge. In order to produce a negative or positive charge, the electrons must be moved while the positive charges in the nucleus do not move.

Contact Charge

Transferring a charge from one material to another material by direct contact.

Induction Charge

Transferring a charge from one material to another without actual contact.

Contact Discharge

Material which is connected by actual contact provides a path for electrons of the negative charge to cross to the positive charge, therefore, the charges would neutralize, this is a contact discharge.

Arc Discharge

Electrons crossing from one material to another material through an arc. This comes about when using materials with very strong charges. The discharge is seen in the form of an arc.

Electric Power

The rate of work done in moving electrons through a conductor.

Magnetism

Magnetism can generate Electricity. When wires move past a magnet or magnets move past a wire, electricity is produced. The electric power a generator produces is a result of action between wires and magnetics inside the generator.

Magnetic Field

A Magnetic Field is invisible lines of force leaving a magnet at one point and entering again at another point. A magnetic circuit is the path taken by the magnetic lines of force. We cannot produce electricity through wire and magnets unless we have movement of the magnet past the wire or visa-versa. We need this movement of wire past the magnet, as a magnetic field around a magnet produces an electric current in a wire, only when the magnetic field is broken by the wire. If the magnet and its field are stationary, the field is not moving across the wire and will not induce a movement of electrons; and it is the movement of free electrons from point to point that causes an electric current.

Generators

The source of electricity produced by a wire traveling in a circle, past magnets, is the principle of the electric generator. The generator is the source of most electricity used for electric power.

Electromagnetism

If we have more wires passing through the magnetic field we would have greater current generated. When we begin to use a coil to break our magnetic field we will also need a stronger magnetic field for a stronger flow of electrons.

To increase the magnetic field we have the means of an electromagnet. The basic principle of an electromagnet is: "A Magnetic field can be generated by passing an electric current through a coil of wire." When electromagnets are used, the strength of the magnetic field can be controlled by varying the amount of current flow through the coils.

DEFINITIONS

Conductor

A conductor is a material which carries electricity, such as a "coil" --- Conductors are usually made of metal such as aluminum, iron, or copper.

Electric Charges and Measurement

The electron is the basic unit of electricity, but being so small it is not a practical means of measurement. Current flow is the measure of the amount of electrons that are passing through a material in a given length of time.

Coulomb

The unit used for measuring the quantity of electric charges. It equals 6.28 Million, Million, Million electrons.

Ampere

By counting the coulombs that pass in a set amount of time, the current flow is measured. An ampere is the unit for measuring current flow. One ampere of current is flowing when one coulomb of electrons pass through a material in one second, etc.

Coulomb - Measure of Quantity
Ampere - Measure of Rate

Ammeter

A meter which indicates on a scale of Amperes, the number of electrons (coulombs) passing per second through the material.

Milliampere

For current of flow below one ampere, we use a unit measure known as the Milliampere.

1 Milliampere = One thousandth Ampere
1,000 x 1 milliampere = 1 Ampere

Milliammeter

A meter which indicates Milliamperes.

Microampere

For current flow below one thousandth Ampere, the unit of measurement is the Microampere.

1 Microampere = One Millionth Ampere
1,000,000 x 1 Microampere = 1 Ampere

Microammeter

A meter which indicates Microamperes.

Meter Reading

In reading ammeters, milliammeters and microameters, the readings should always be taken from a position at right angles to the meter face. Taking a reading from another angle will result in a Parallax. Most readings usually being slightly inaccurate, plus a Parallax, will result in a very inaccurate reading.

Electromotive Force EMF

Electromotive Force is the moving force which causes current flow, when electrons move from a less positive charge to a more positive charge, this is electromotive force and is the moving force that causes current to flow.

Voltage

To know the answer to voltage we acknowledge first that an electric charge, (positive or negative), equals a reserve of energy, and as long as this energy is not being used, it is called Potential energy. Voltage is the potential of each charge and also the difference in potential between each charge. The difference in potential between two charges is the electromotive force acting between the charges. This is known as "Voltage."

When we have any two charges which are not equal, we have a difference in potential (Voltage). Voltage is used to show the relation between one charge and another and to show the electromotive force between the two charges being compared. The greater the Electromotive force (Voltage) between the charges, the greater the current flow. The value of voltage (EMF) determines how much current will flow.

Units of Voltage

For Voltage less than one volt, we use the Millivolt and Microvolt. When the potential difference between two charges is between one-thousandth of a volt and one volt, the unit measure Millivolt is used. When the potential difference is between one thousandth and one-millionth, the unit of measure is the Microvolt. For Voltage more than 1,000 volts we use the unit of measure called the Kilowatt. (Kilo means one thousand.)

Voltmeter

A voltmeter is the means by which voltage is measured.

Resistance

Resistance is determined by the number of free electrons in a material.

DEFINITIONS

The atoms of some materials will give up their outer electrons easier than other materials that hold their outer electrons. The atoms that give up outer electrons easily cause little resistance to current flow, while the atoms that hold their electrons will cause a large extent of resistance. All material has some opposition to current flow, this is resistance. When we can increase or decrease the amount of resistance (the opposition to electron movement,) in a circuit, we can then adjust the amount of current flow to satisfy the piece of electrical equipment in operation.

<u>Resistor</u>

There is resistance in all of the electrical equipment which we use. Sometimes the resistance present is not enough to control the flow of current at the desired amount. A device that is used to add additional resistance is called a resistor. Some have fixed value, others are variable. Wire wound resistors are used to control large currents, while carbon resistors are used to control currents which are small. Resistors are color coded for finding the value; if they are not marked, we must use the Ohmmeter.

<u>Circuit</u>

A circuit is a completed electric pathway where we have current flowing not only through a conductor where the current flows from a negative to a positive charge, but also flows through a voltage source from the positive charge back to the negative charge.

<u>Switch</u>

A device which is used to open and close a circuit when desired.

<u>Fuses</u>

Fuses are metal resistors with low resistance values, and are designed to blow out when the current exceeds its safe limit in a circuit.

<u>Circuit Symbols</u>

Most electrical circuit connections are shown in symbol form, not only being used to show the type of equipment used and to show circuit connections, but also are used to express current, voltage and resistance.

EMF = Electromotive Force	I = Current
R = Resistance	P = Power
V = Volts	A = Amperes
Ω = Ohms	W = Watts

<u>Series Circuit</u>

If we have all of our resistances around a circuit connected end to end so we only have one path of current flow, we have a series circuit.

Resistance in Series Circuits

The rules for resistance in series is "In series, resistances add." This speaks for itself, an example of this would be: We have two lamps or two resistances on a circuit, one lamp has a resistance of 4 Ohms and the other a resistance of 5 Ohms, the total resistance is 9 Ohms in the lamps.

If we use more than one of the same device, such as three resistors, we need something other than "R" to distinguish each resistor from another. A "subscript" is used such as  R_1, the 1, 2, 3, etc. being subscripts, however, the marking serves only as an indication of individual devices or quantity. It does not indicate a value.

Current Flow in Series Circuits

Being there is only one path for current flow in a series circuit, all current flow must pass through each resistance in the circuit; therefore, all paths of the circuit must be able to hold the maximum current which flows. The only way this can be accomplished is by the total resistance being large enough to reduce the amount of current to a value which can be safely passed by all the circuit resistances. The current is the same through all paths of the circuit.

Voltage in Series Circuit

The voltage across each resistance is only part of the total voltage and depends on the value of each resistor; the sum of the voltage drop equals the total voltage.

Whenever a force is exerted to move an object against some form of opposition, this force is expended. In Electricity, this is called "Voltage Drop" (IR). As the Electromotive Force (EMF) moves through a resistor, force is expended, we then have a voltage drop.

Open Circuit

An Open Circuit is any break in the closed circuit path which causes current to stop flowing, and can be caused by loose connections, burned out filaments or resistors, loose contacts, broken wires, etc.

Short Circuit

A Short will occur when the resistance of a circuit or part of a circuit drops from its normal value to zero resistance. This happens when bare wires contact, wiring is improper, etc. When the resistance of the circuit to current flow is zero, a large current then flows, and can damage meters or other equipment. So to avoid relying on fuses to open the circuit, we can avoid short circuits by using caution in all electrical connections.

DEFINITIONS

Conductor

Materials that offer very little resistance to the flow of current and have a large supply of free electrons are used to carry or conduct electricity. Metals are the best conductors.

Insulators

Materials used to block the flow of current conduct the flow of electricity but in a very much smaller quantity than a conductor, flow in an insulator is considered to be zero.

Units of Resistance

To measure current, the ampere is used; and to measure voltage, the volt is used. A unit of measure to compare the resistance of different conductors is the Ohm.

Ohms Law

Mr. George S. Ohm set down the unit for measuring resistance, it is known as the Ohm. The law reads:

1. Current in a circuit increases when the voltage is increased for the same resistance.
2. Current in a circuit decreases when the resistance is increased for the same voltage.

Combine these two rules and we have Ohms law, the most basic law of electric circuits. Current flows in a circuit because electromotive force (e.m.f.) or voltage, forces it to flow, and by resistors the amount of current is limited, so the amount of current depends upon the amount of electrical pressure, or voltage, and the amount of resistance.

The most common way of expressing Ohm's law is this, "the Current flowing in a circuit is directly proportional to the applied voltage, and inversely proportional to the resistance."

Ohms' law is used in electricity in place of a meter to find an unknown factor concerning a circuit or part of a circuit when two of the factors are known. We can use this law in place of an Ohmmeter, Voltmeter, or Ammeter to find resistance, voltage, or current, provided you know two of the quantities and desire to find the third quantity.

Volts = Amperes X Ohms = Example

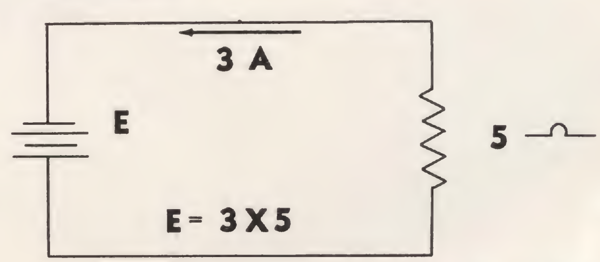
$$E = IR$$

Amperes + Volts ÷ Ohms

$$I = \frac{E}{R}$$

Ohms = Volts ÷ Amperes

$$R + \frac{R}{1}$$



DEFINITIONS

Microhm - Megohm - Kilohm

As in Amperes and Voltage we need in Ohms a unit which will measure values more than one million Ohms. Fractional values of resistance are measured by Microhms and very large values are measured by the units of Megohms, one thousand and one million are measured by Kilohms.

One Microhm = One-Millionth Ohm
One Megohm = One Million Ohms
One Kilohm = One thousand to One Million Ohms

Ohmmeter

To measure voltage and current we use a voltmeter and ammeter. To measure resistance, we use an Ohmmeter.

Electrical Power

Mechanical or electrical power is the rate of work being done when mechanical or electrical force moves an object, motion is caused or work is done. In electricity we know that the movement of work is carried out by electrons.

Watt

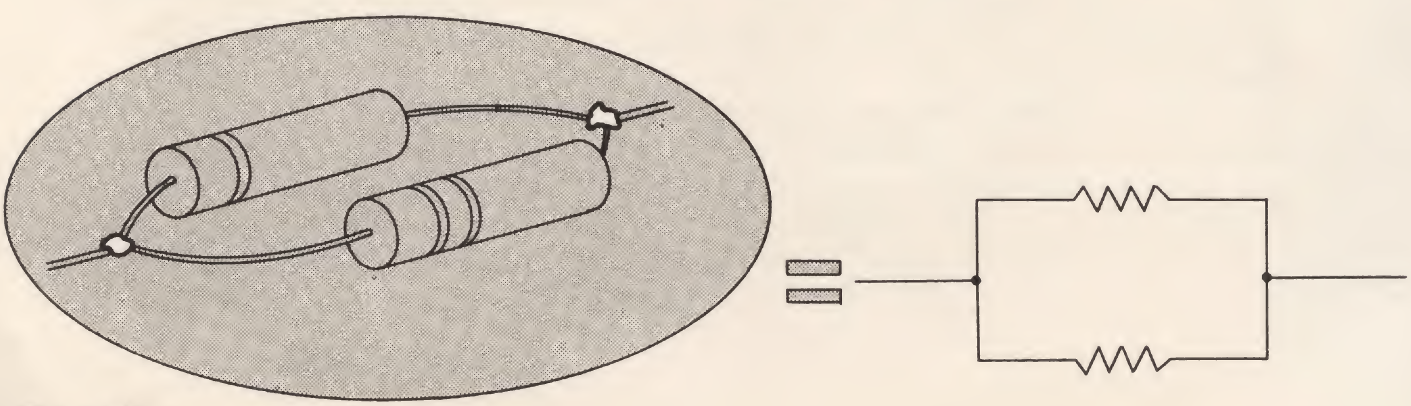
The basic unit of power is the watt, which equals the voltage multiplied by the Current.

Power = Voltage X Current

The Watt represents the rate at which work is being done in moving electrons through a material. Watts are generally used to indicate the power rating of electrical equipment. Such a power rating of equipment is indicated by the rate at which electrical energy is changed into some form of energy, such as heat or light. If the rated voltage on the equipment or device is exceeded, the machinery will overheat and be damaged.

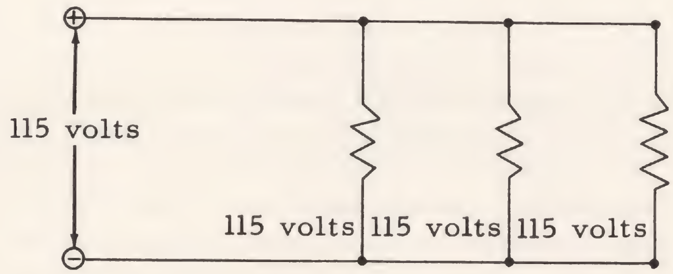
Parallel Circuits

Parallel Circuits,instead of being end to end connections as in Series Circuits, are resistances connected side by side across a voltage source, providing more than one path for current flow.



Voltage In Parallel Circuits

When we have Parallel Resistances connected across a voltage source the same voltage is introduced to each resistance and is equal to the voltage source. The current, however, depends on the values of resistance in each separate resistor. All parallel circuits, which are to operate correctly, must have the same voltage rating. Due to the resistors, each may pass a differing amount of current.



Current is always greatest through the path of least resistance. The rule is: Branches in a parallel circuit with low resistance will draw more current than branches with high resistance, regardless of the form of resistance. The current devides to flow through the parallel branches of the circuit.

Parallel Circuit Resistance

The total resistance is less than that of the smallest individual resistance. A Parallel connection, or two equal resistances connected in parallel will pass twice as much current as a single resistance, therefore, a greater current flow indicates that the total resistance of the parallel-connected resistance is less than the resistance of a single resistance.

A.C. and D.C. Current Flow

Alternating current is preferred for many uses over direct current. Alternating current voltage can be raised or lowered easily, without much power loss whereas D.C. Current cannot be increased or decreased without considerable power loss. Different equipment requires different voltage for proper operation and all can be accomplished by use of a transformer and A.C. power line. A D.C. line is complicated and inefficient.

Alternating Current

An alternating current flows, first one direction and then changes and flows in the opposite direction, at regular intervals.

Direct Current

Direct Currentflows only in one direction.

By using A.C. circuits we can have high voltage, lower current. Because current is measured by the amount of electrons flowing past a point in a circuit in one second, A.C. current keeps the current value low. It does not cause the wires to overheat because of excessive current, also we can keep the voltage at an increased rate permitting the transfer of large amounts of power with small wires and a low power load.

Transformers

When we transmit A.C. power at high voltage, low current level, the generated voltage is fed into a transformer. A transformer raises and lowers A.C. Voltage. At the generated point the Voltage is raised and a large amount of Power transmitted, at the load end of the line, another transformer will reduce the voltage for distribution. Sub-stations decrease the voltage to 220-110 volts for local power use. The transformer does not generate electric power, it transfers electric power from one coil to another by magnetic induction, increasing or decreasing the voltage as needed.

Generators

The Basic Principle of the Generator is that we can generate Electricity by moving a Conductor through a Magnetic field. Generators are the prime source of electrical power. When there is no motion of the conductor through the magnetic field we have no electricity generated. Generated Electricity is called voltage, actually "induced voltage", and the method described to generate this induced voltage is called "induction".

The boilers of the furnace in a modern generating station for public electricity supply, are as high as a ten-story building. Tubes in the boiler are filled with water which when exposed to the intense heat of white-hot flame from burning fuel (pulverized coal, oil, natural gas) is converted into steam at 1500 pounds pressure. In each boiler 850,000 pounds of water per hour are converted into steam. The steam is so hot that it makes the pipes that carry it glow dull red. The temperature of the steam is as high as 1050 degrees Fahrenheit.

Each boiler consumes 950 tons of coal or 160,000 gallons of oil per day, enough to last the average home owner 80 years.

A modern generating plant can produce a kilowatt-hour of electricity from slightly less than three-fourths of a pound of coal.

The turbine shaft and generator shaft which are connected, weigh 80 tons, but still they spin at the terrific speed of 3600 revolutions per minute. The steam is later converted back to water by a cooling condenser through which 135,000,000 gallons of cold water is pumped daily. The 100,000 kilowatt generators are totally enclosed and filled with hydrogen for cooling purposes.

As the loop of wire cuts through the Magnetic field, an induced e.m.f. (Voltage) is generated and causes the current to flow. The ends of the armature loop are connected to the slip rings which in turn rotate with the armature, the slip rings riding against brushes, the brushes picking up the generated electricity from the armature, and carrying it to the external circuit.

Induction

When circuit current increases or decreases, the magnetic field will increase or decrease with it. This expansion and contraction is known as inductance. This inductance, when in action opposes the change in current flow, and is measured in Henries by the letter L.

Inductor

A coil of wire can be used to cause Induction.

Note: By the use of a shorting switch the current is changed, flux lines reduced and current can be transferred from one circuit to another. This is explained fully in a study of Michael Faraday's law of electromagnetic induction.

Inductive Reactance

The opposition flow of current caused by inductance is know as inductive reactance.

Capacitance (Capacitor)

A Capacitor or Condenser is basically an instrument for holding or storing an electric charge, an accumulator for electrical energy. When the voltage of an electric circuit changes, the circuit opposes the change in electrical value. This is capacitance. Capacitance is present in every electrical circuit whenever the voltage increases or decreases. Capacitance delays the change in voltage but does not prevent the change.

Units of Capacitance

The Basic unit of capacitance is the Farad, however, as the unit Farad is so very large in storage capacity, the basic units for practical electrical circuits are:

Microfarads (One Millionth Farad)

$$1 \text{ m.f.d.} \quad \frac{1 \text{ farad}}{1,000,000}$$

MicroMicrofarad (One Millionth, millionth of a farad).

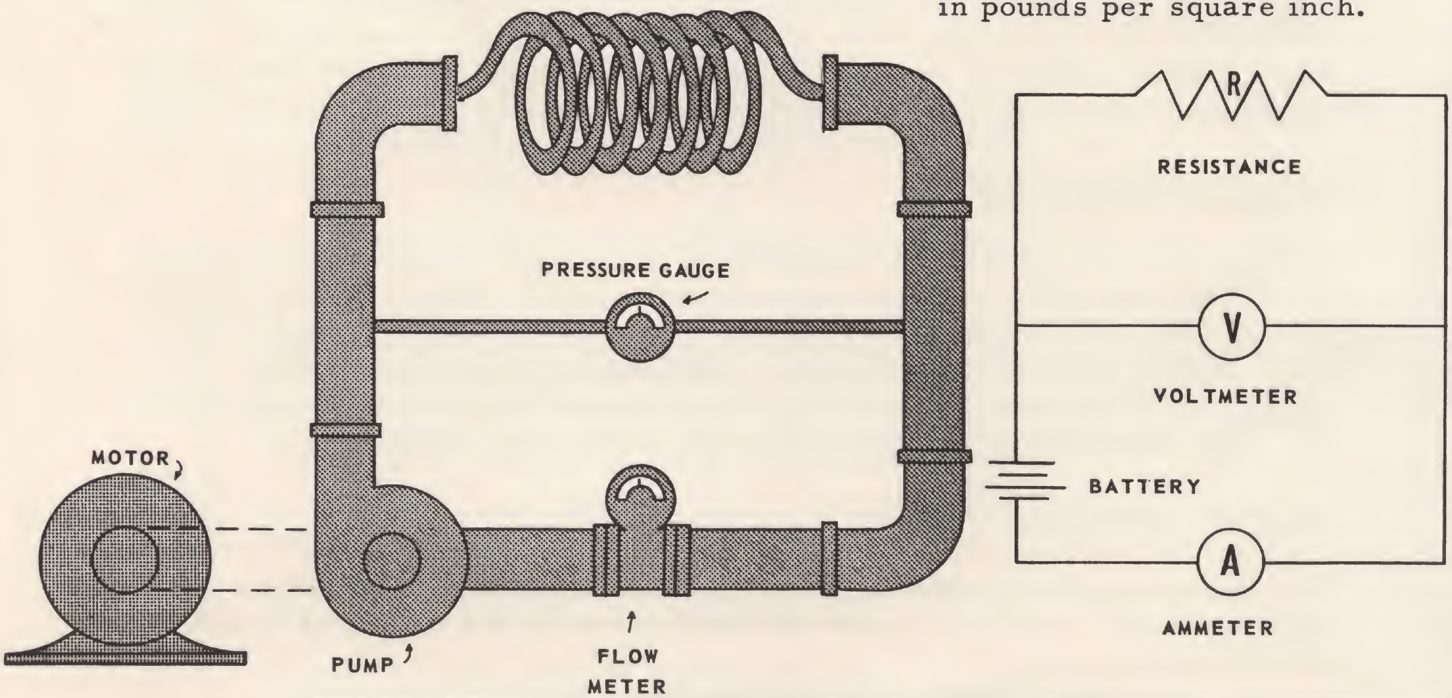
Capacitors consist of two metal or foil plates and an insulating material called the "Dielectric". As with resistors, capacitors also have a "Color Code".

OHM'S LAW. In order to obtain a better understanding of electrical circuits, use can be made of the old but still useful fluid analogy. In the illustration below a pump is shown driven by a motor. This pump is used to circulate oil* through a cooling coil of small copper tubing. A guage is connected to the ends of the copper tubing to measure the difference in pressure across the coil and a flow meter is inserted in the pipe to measure the rate at which the oil flows through the tubing.

If the speed of the pump is changed and if readings are taken of the pressure gauge and flow meter at each pump speed, a set of data will be obtained as shown in the table below the illustration. It is important to observe that at each pump speed, the pressure, divided by the flow, gives the same result. In this case that value is 12.5. The flow at any pressure can, of course, be found by dividing the pressure by 12.5. If the flow is desired at some pressure other than those tested, it might also be obtained by dividing the pressure by 12.5.

Example: What is the flow at 50 lb per square inch pressure? According to the relation stated above,

$$\text{flow} = \frac{\text{pressure}}{12.5} = \frac{50}{12.5} = 4 \text{ gallons per minute, pressure being in pounds per square inch.}$$



PRESSURE (lb/in²)	FLOW (gal./min.)	PRESSURE / FLOW
20	1.6	12.5
35	2.8	12.5
75	6.0	12.5
100	8.0	12.5
150	12.0	12.5

ELECTRIC PRESSURE (Volts)	ELECTRIC FLOW (Amperes)	VOLTS / (Amperes)
8.0	0.92	8.7
12.0	1.38	8.7
16.8	1.93	8.7
22.4	2.57	8.7
47.0	5.40	8.7

'ANALOGY BETWEEN HYDRAULIC AND ELECTRIC CIRCUITS'

The constant 12.5* is characteristic of this particular size and length of tubing and so can be called the resistance of the coil of tubing.

To the right of this simple hydraulic circuit is shown a similar electric circuit. A battery supplies the electric pressure that causes an electric current to flow through a coil of copper wire indicated diagrammatically at R. The meter used to measure the electric pressure in volts is called a voltmeter. The meter used to measure the current in amperes is called an ammeter. If taps are arranged on the battery so that different voltages may be applied to the coil of wire, then a set of readings of volts and corresponding amperes can be made. These readings would be comparable to the pressure and flow readings of the hydraulic circuit. In the electric circuit the voltmeter reading divided by the ammeter reading is always 8.7 and this constant is called the resistance. It is seen by this analogy that in the electric circuit also it is possible to predict the current flow with any given voltage. For instance, if the current corresponding to 65 v were desired, then

$$I = \frac{E}{8.7} = \frac{65}{8.7} = 7.5 \text{ amp},$$

E being in volts, this value of 8.7 is a characteristic of the wire and is called the resistance. It is measured in the unit which has been defined as the ohm. The formal statement of the relationship observed above is as follows:

"The current in amperes is equal to the pressure in volts divided by the resistance in ohms."

This statement is known as OHM'S LAW and is the basis for a large portion of electrical circuit theory. It may be expressed mathematically in the three forms below:

$$I = \frac{E}{R} \qquad R = \frac{E}{I} \qquad E = RI.$$

A word of caution should be given at this time, for although this is the general rule of behavior of electrical circuits, there are many exceptions. Many of these cases of unusual behavior are the basis of the operation of important commercial equipment. No great worry should, therefore, be caused the student when he later meets with these exceptions.

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*Oil is used instead of water because it is a liquid of high viscosity and will obey the Ohm's Law of the hydraulic circuit.

*This constant depends also upon the viscosity of the fluid. In electricity the variable corresponding to viscosity does not occur.

SERVICE LITERATURE IN YOUR BRANCH LIBRARY CONTAINING INFORMATION ON ELECTRO-MECHANICAL PRODUCTS

SYNCHRO BULLETINS

S 501, S 502, S 503, S 504, S 505, S 506, S 507
S 2-501
S 4-501, S 4-502, S 4-503, S 4-504, S 4-505, S 4-506, S 4-507, S 4-508
S 4-509, S 4-511, S 4-512
S 6-501, S 6-501A, S 6-501B, S 502

LISTER BULLETINS

B-515, B-516

SPECIAL SERVICE LETTERS

119A, 120, 120A, 121, 122A, 123, 125, 126, 127, 128, 130, 131A, 132, 133, 134, 135, 136, 137

PARTS IMPROVEMENT NOTICES

S-1, S-3, S-4, S-5, S-6, S-7, S-7A, S-8, S-9, S-10, S-11, S-12, S-13, S-14

CHANGE IN NUMBER NOTICES

CINN 3, CINN 9, CINN 14

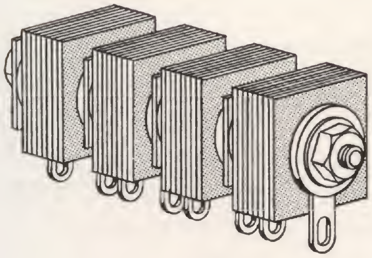
ELECTRONICS

A set of special service letters is available to men who have completed training at Monrobot schools conducted at Orange.

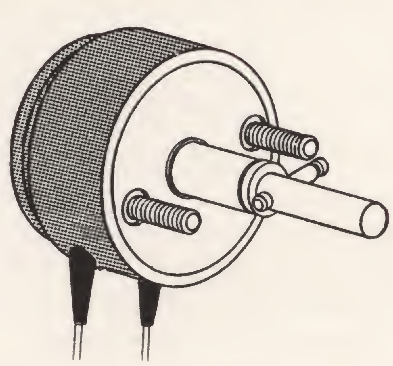
THE CONTINUING SEARCH FOR KNOWLEDGE

Some very good courses in 'Electricity' are available in adult evening classes held in public schools, for a small fee. In some areas, vocational schools and technical high schools offer free 'Radio' and 'Television' training programs. Have you considered availing yourself of this beneficial schooling?

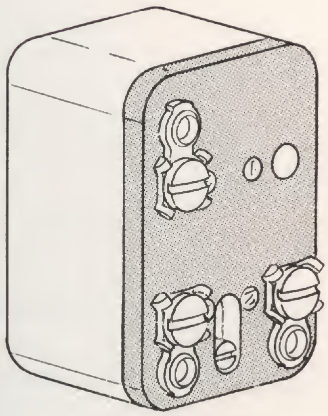
SOME ELECTRICAL COMPONENTS USED IN MONROE PRODUCTS



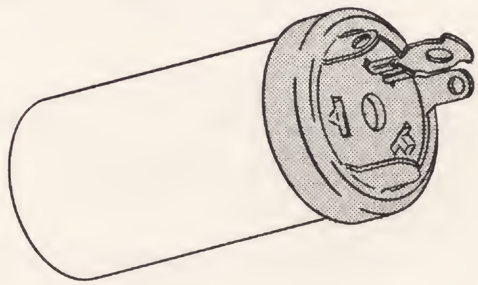
RECTIFIER



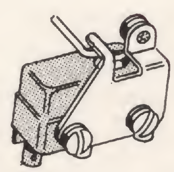
SOLENOID



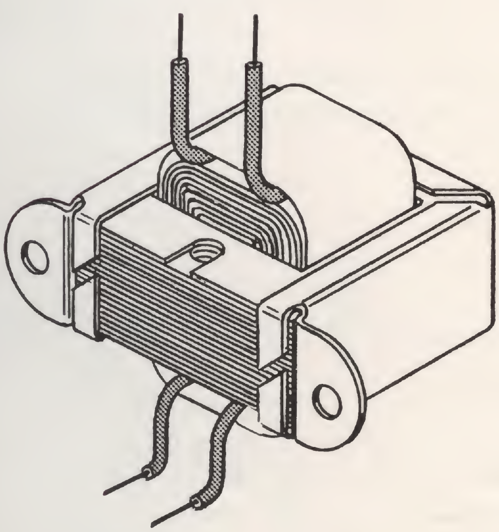
RELAY



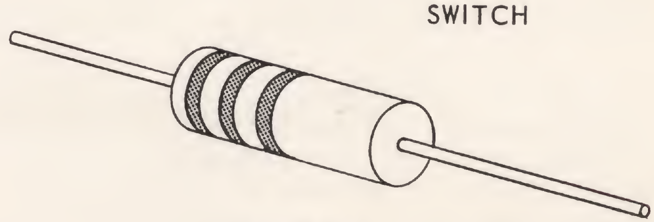
CAPACITOR



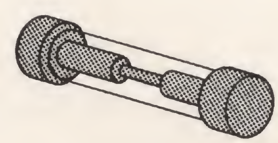
SWITCH



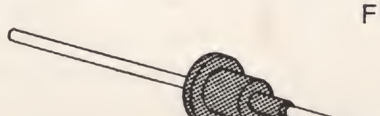
TRANSFORMER



RESISTOR



FUSE



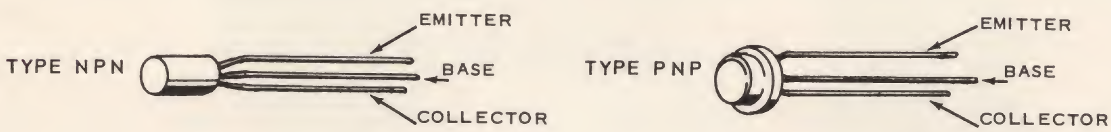
DIODE

THE **TRANSISTOR** (TRANSfer resISTOR)

The Monroe Usage of This Current Amplifier

Monrobots X and XI employ transistors whereas the IX uses vacuum tubes. The tiny transistor in our electronic computer is capable of providing longer operating life as compared to the vacuum tube, and it requires less power to operate, thereby reducing undesirable heat. In addition to these advantages the transistor permits more compact design and smaller size machines and reduces operating costs. Servicing of computers is simplified through use of transistors instead of vacuum tubes and their costly and cumbersome components.

TRANSISTORS USED BY MONROE



Engineers working with a grayish-white, brittle, metallic element known as Germanium, discovered unusual electrical properties about it. Subsequent extensive research in the laboratories of the American Telegraph and Telephone Company resulted in the development of the first transistor twelve years ago. With silicon and germanium materials known as "semi-conductors" (they conduct more current than an insulator, but less than steel or copper), the researchers combined element compounds of crystalline structure, tin-white in color (and very poisonous). By so doing, these compounds (IMPURITIES) such as arsenic, can cause an overabundance of electrons or a shortage of them.

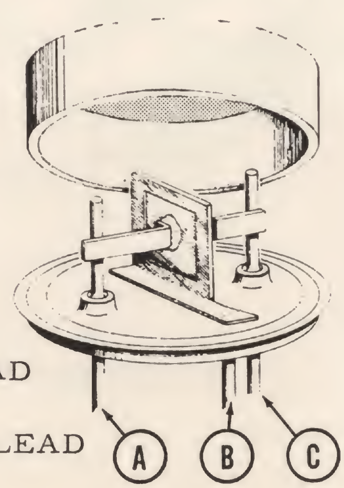
The three elements of a transistor are EMITTER, BASE and COLLECTOR. The emitter throws off electrons, the collector gathers electrons and the base regulates the flow.

TRANSISTORS ARE EXPENSIVE

. Do not subject them to heat
. Do not use or store in a damp place
. Do not drop or subject them to shock
. Do not apply sudden voltage

INTERNAL VIEW OF TRANSISTOR (Greatly Enlarged)

A = EMITTER LEAD
B = BASE LEAD
C = COLLECTOR LEAD



QUESTIONNAIRE

BOOK NO. 6

STUDENT ______________________________ BRANCH ____________________ DATE ________

DIVISION EXAMINER ________________________________ RIGHT ________ WRONG ________

1 Q. Who is known as "The father of electrical science?

A.

2 Q. What is the speed of electric clocks dependant on?

A.

3 Q. When electricity leaves the generating machine it is described as being ____________ ____________ A.C. at a ____________ of ____________ C.P.S. (What are the four missing words?)

A.

4 Q. (a) What is considered "The heart of the automobile"?

(b) This system is ____________ operated. (What is the missing word?)

A.

5 Q. What is the difference between the terms, "Power" and "Work?

A.

6 Q. Name one type of motor used in our mechanical equipment?

A.

QUESTIONNAIRE

7 Q. List five products manufactured by Monroe that use electrical devices in addition to motors.

A.

8 Q. Define the following: (a) Volt, (b) Ampere, (c) Resistance?

A.

9 Q. What is the value of a resistor color coded; 1st band-black, 2nd band-red, 3rd band-green, 4th band-silver?

A.

10 Q. What is to be observed when replacing an electrolytic capacitor?

A.

11 Q. When capacitors are connected in series, the total capacitance is ______________?

A.

12 Q. When a capacitor is charged in one direction, it will discharge in the ______________ ______________?

A.

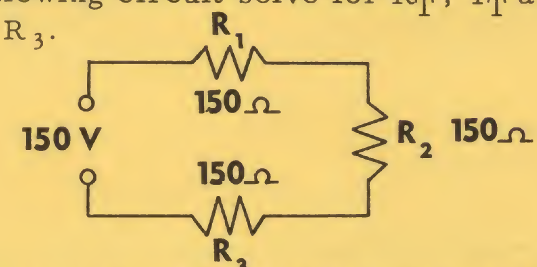
13 Q. Write the algebraic expression for Ohms Law. (D.C.)

A.

QUESTIONNAIRE

14 Q. In the following circuit solve for R_T, I_T and the voltage drop across R_1, R_2, R_3.

A.



15 Q. In what circuit is the total resistance less than the lowest resistor?

A.

16 Q. (a) In what circuit is the voltage equal everywhere?

A.

Q. (b) In what circuit is the current equal everywhere?

A.

17 Q. How may the solving of a series-parallel resistor circuit be simplified?

A.

18 Q. What is a common result of opening a switch in an inductive circuit?

A.

19 Q. What is a bridge type rectifier circuit used for?

A.

20 Q. List five instruments used in the measuring of electrical (electronic) operations.

A.

QUESTIONNAIRE

21 Q. Identify the following symbols.

(a) E
(b) R
(c) Ω
(d) I
(e) A
(f) 

A.

22 Q. Why is A.C. preferred over D.C. ?

A.

23 Q. What is the basic principle of the generator ?

A.

24 Q. What analogy can electrical circuits be made to?

A.

25 Q. List five electrical components used in Monroe products?

A.

26 Q. Name two types of transistors.

A.

27 Q. List three precautions that should be taken in the handling of Transistors?

A.

QUESTIONNAIRE

28 Q. Is "electron" the same as "elektron?

A.

29 Q. What is one of the inherent characteristics of electricity?

A.

30 Q. What is the common measure of power in engineering?

A.

31 Q. Power in watts is the product of the volts times the ____________ in the circuit. (Fill in the missing word.)

A.

32 Q. The names of what men are today electrical terms?

A.

33 Q. Is the use of electricity new to Monroe Products?

A.

34 Q. When not under load, at what R.P.M. speed will the universal motor of a Monroe calculator operate? ('N' Model)

A.

QUESTIONNAIRE

35 Q. The unit for measuring resistance is the ____________ . (What word should be placed in the blank space?)

A.

36 Q. What happens when current passes through a resistor?

A.

37 Q. What is the "Delta Formula"?

A.

38 Q. When a bar of iron is placed in a coil of wire and current flows, what happens to the iron?

A.

39 Q. What is a characteristic of a rectifier or diode?

A.

40 Q. Draw below the electrical symbol for a "cannon" connector.

A.

41 Q. To change Units to Mega-Units what figure do you multiply by? Divide by?

A.

QUESTIONNAIRE

42 Q. Do you believe Benjamin Franklin held the cotton string or the silk rope in his hand during his famous experiment with the key and lightning? Why do you believe so?

A.

43 Q. Now that you have studied all six training books do you believe they have aided you in obtaining a sound understanding of Monroe fundamentals?

A.

44 Q. Are the service bulletins, catalogs and other service publications, more understandable to you now since reading the six yellow service training books?

A.

45 Q. What, in your opinion can be done from here on to further assist you in furthering your acquisition of technical know-how of the workings of Monroe Products?

A.

46 Q. Do you know that many other kinds of publications are available to help you in servicing Monroe Machines? There are hundreds of Machine Service Bulletins, Catalogs, Manuals, Special Service Letters, Parts Improvement Notices, Change in Number Notices, Orangeaids, Sketches, Data Sheets, etc., containing detailed information.

A.

A SERVICE FOUNDATION

This is the final release in the series of six 8½"x 11"service training books, intended to simplify and expedite the training of new field servicemen. We trust that the study of these books has instilled a desire to master the mechanisms and workings of all Monroė products by a continuance of schooling.

Interest and advancement in electricity may be continued by studying 'Basic Electronics', volumes 1 to 6 inclusive, and 'Basics of Digital Computers', volumes 1 to 3 inclusive. These books by Van Valkenburgh, Nooger, and Neville, Inc. and published by John F. Rider, Inc., New York City, may be purchased locally or through the General Service Department.

NOTICE

CREDITS

Acknowledgment is hereby made of the preparation of section 'H' in this book by Mr. G.B. of the Electronic Section of the General Service Department and Mr. A.H. of Field Division #8. Appreciation is also extended to Public Service Electric Corporation of N. J. for excerpts in sections 'B' and 'C'.

George H. Fryer -- Editor